

A MANUAL OF [illegible]UE

A MANUAL OF PLAGUE

BY

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WITH AN INTRODUCTION

BY

SURGEON-GENERAL G. BAINBRIDGE, M.D., M.R.C.P., I.M.S.



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To

MY BROTHER OF[illegible]

IN THE

INDIAN MEDICAL SERVICE

INTRODUCTION

BY

SURGEON-GENERAL G. BAINBR[illegible]E, I.M.S.

In commending this work to the [illegible]ber of [illegible] medical profession, and particularly to those to whom it has been inscribed, I submit that my long acquaintance with the disease and with its management in India justifies my belief that the object of the author—viz., the production of a concise Manual of Plague—has been adequately attained.

Careful revision of the principal chapters convinces me that nothing which is worth recording has been omitted, and I consider the work to be an accurate exposition of our present knowledge of plague, the more acceptable and useful by reason of its freedom from controversial matter.

Six years' continuous connection with plague administration, in all its branches, has not only given Major Jennings opportunities for intimate

association with many of the scientists who have been striving to elucidate the different problems, and the officials who have been carrying out preventive and other measures, but has also led him to test their conclusions. He therefore seems fully entitled to undertake a work of this kind, whilst his own experience enables him to give special p[illegible]ence to such points as are likely to be of m[illegible]tical utility in dealing with future outbrea[illegible]

In conclusion, [illegible] have no hesitation in saying that, both as an interesting compilation and as a practical guide, the Manual should supply a keenly-felt want.

G BAINBRIDGE, M.D, M.R C P., I M S,
Surgeon-General with the Government of Bombay

October 15, 1902

AUTHOR'S PREFACE

WITH a view to obviating what is [illegible] drawback to the daily increasing number of [illegible] called upon to deal with epidemics of plague—viz., the want of a manual comprising, in a readily accessible and systematic form, the conclusions which have been arrived at as the most probable solutions of the many questions regarding which only conjecture was possible before opportunities were afforded for investigation by modern scientific methods—I have, at the suggestion of several brother officers and fellow-workers, been led to undertake the preparation of a convenient handbook for ready reference, comprising all that is known, with any degree of certainty, regarding the attributes of the infective agent; the clinical, pathological, and epidemiological features of the disease; and the methods of treatment and prevention

It is true that such an undertaking may, in some respects, emphasize the fact that much still remains obscure, but as scant illumination in a dark place may often serve to reveal a pathway to a desired goal, so the fact that we have still a good deal to learn does not necessarily imply that the light to which we have attained falls short of what is sufficient to guide us to the adoption of methods upon which we can with certainty rely; and, indeed, it may be safely asserted that it does not

I claim no originality in the following pages; but, while I have endeavoured to attribute all particular discoveries to their discoverers, I have refrained from hampering the work with references to authenticate facts which have been independently arrived at by different investigators, as well as by personal observation I have also omitted to include the controversial matter which has led to the formulation of theories advanced in connection with points regarding which convincing testimony is still wanting. For these the reader is referred to the numerous sources of information which have been accumulating during the past several years, including reports upon special points, contributions to the medical press, papers read before

learned societies, Government blue-books, treatises and pamphlets in support of particular views, and reports of special Plague Commissions, amongst which last the exhaustive and valuable report of the Indian Plague Commission takes the foremost place.

I am deeply indebted to Surgeon-General Bainbridge for having revised the principal chapters, for having written an introduction to this work, and for many valuable suggestions My thanks are also due to Mons William de Klemme, Consul-General in India for the Russian Empire, for having obtained for my use a copy of the report of the Russian Plague Commission, to Herr Heinrich Fehlitschka, Consul for the Austro-Hungarian Empire, for a copy of the report of the Austrian Plague Commission; to Mr F B Stewart, photo-artist, Poona, for permission to reproduce some photographs from the Bombay Plague Committee Album, of which he holds the copyright, and to Mr Richard Muir, of the Edinburgh University, for placing at my disposal several microscopical sections prepared by him

In an introductory chapter, among other historical allusions, I have quoted the report and recommendations of an ancient Plague Commission, which, I trust, will not only prove of interest, but will also

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illustrate the condition of medical science during the prevalence of the outbreaks commonly referred to as the Black Death of the fourteenth century.

If to the clinician the work should prove to be of use in indicating which, among many, lines of treatment have given the best results in the past; to the student what is known and what has yet to be learned; and to the administrator what measures experience has shown to be useless, and upon what we should mainly rely, I shall feel amply rewarded for the labour which I have expended upon its production.

LONDON,
April, 1903

LIST OF ILLUSTRATIONS

A MANUAL OF PLAGUE

CHAPTER I

INTRODUCTORY

ERRATA IN INDEX

Balfour Stewart, read 28 for 29.
British Medical Journal, read 28 for 29 and 31 for 32.
Excretions, read 34 for 35.
German Plague Commission, omit 34
Guinea Pigs, read 31 for 32
Mice, add P 31
Rabbits, read 31 for 32.
Rats, read 31 for 32
Secretions, read 31 for 32.
Simpson, read 31 for 32.
Sputum, read 34 for 35
Squirrels, read 31 for 32

the glandular regions. and, occasi

N B.—Plates X. to XV. are reproduced from the Bombay Plague Committee Album, compiled by Mr F. B Stewart, photo-artist, Poona.

The Black Death of the fourteenth century, the most terribly fatal epidemic on record, is considered by some writers to have been a different disease, though possessing some characters in common with the plague, and to have commenced and ended with that epidemic, being now extinct. The arguments advanced by them in favour of this view have reference to the testimony of writers of the time that, whereas in previous epidemics the infection had been introduced from Egypt into Russia, the Black Death came from Cathay in the North of China, and to the fact that the leading feature of the disease was the great prominence of symptoms referable to the respiratory system, including severe thoracic pain, gangrenous inflammation of the lungs, and hæmoptysis Absence of precedent and of analogy render most improbable the assumption that any disease could, after one terribly fatal manifestation, become extinct, so the identity of the two diseases need not be rejected on the ground of variation in general characters And in further refutation of the first argument, in favour of duality, we have the testimony of Russian chroniclers, as pointed out by Dr. Clemow in a pamphlet on plague epidemics in Russia, that, while the Greek, Italian, and other Western writers regard China

ment of one or more of the other systems (especially the respiratory, central nervous, and cutaneous); a disease, though reputed to be endemic in some areas, occurring generally, at long intervals, in epidemic or pandemic form.

Though opinions on the subject are divided, the greater bulk of evidence goes to prove that the epidemics which have been so widely prevailing during the past few years are identical in character with the many great plague epidemics of which we have historical evidence dating as far back as the third century B.C. Taking, for example, one of the most ancient, that alluded to by Josephus in book vi., chapter i., of the 'Antiquities of the Jews' (of which we also read an account in Old Testament Scripture in the First Book of Samuel), its association with emerods in the secret parts (probably inguinal buboes), with vomiting ('before the soul could, as usual in easy deaths, be well loosed from the body, they brought up their entrails, and vomited up what they had eaten'), with hæmorrhages ('they died of the dysentery and flux'), and with rats ('a great multitude of mice arose out of the earth, and hurt them'), affords fair presumptive evidence that that scourge was none other than plague.

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or Cathay as the place of origin of this epidemic, they (the Russians) state that it came by two routes: the first from the south-east, from India, through the Caucasus and up the Volga; and the second from the north-west, by way of Pskof and Novgorod. As to the other argument, it is now well established that there is a distinct pneumonic type of plague, which is extremely infectious and very fatal. That this type predominated during that terrible visitation is not improbable, though it is difficult to understand why it has not been a prominent feature of any of the other great historic epidemics; it is probable that it did exist, and that its symptoms were attributed to other causes.

Our real knowledge of old epidemics, however, is at the best very uncertain. There is much literature on the subject, but most of it is of little or no scientific value, and reliable premises are wanting for any logical deduction on most points. Such details, nevertheless, of clinical significance as can be gleaned therefrom are not only of present interest, but should also prove instructive by preparing the observer to recognise, as occasional manifestations of plague, symptoms which have not been common features in the recent outbreaks, should they appear; and there is hardly one of those mentioned by the

old writers which has not been observed during the past few years.

Josephus, writing of an outbreak long before the Christian era, alluded to varying forms in the words, 'Nor did they die after one and the same manner, nor so that it was easy to know what the distemper was.'

Gibbon, writing of an outbreak in the time of the Emperor Justinian (A.D 542), states that 'the fever was often accompanied by lethargy or delirium ; the bodies of the sick were covered with black pustules or carbuncles, the symptoms of immediate death ; and, in the constitutions too feeble to produce an eruption, the vomiting of blood was followed by a mortification of the bowels.'

Shafonski, a Russian writer, in describing the clinical aspect of the disease, includes, among such well-known symptoms as buboes, pyrexia, hæmorrhage and delirium, the following which are less well-known, viz. : wheals or vibices and blue spots, large and small, as though the body had been beaten, which generally appear before death when they are present, but often after it in those who die rapidly ; carbuncle, which he classifies as the first and most decisive external sign of the plague ; and diarrhœa, often so profuse that no remedy was able

to check it, in which case it was the direct cause of death.

Drs. Whyte and Gilder, in reporting upon an outbreak in Kathiawar early in the nineteenth century, both recognised a pulmonary as well as a bubonic form The former, describing a typical pulmonary case, drew attention to the fact that there was in the patient's mind a degree of anxiety altogether disproportionate to the apparent symptoms; that all his consideration seemed absorbed with a pain in his chest, upon which he dwelt with a look of most painful distress.

In a description of the symptoms of cases met with in the Pali outbreak of 1838, Assistant-Surgeon Maclean also distinguishes between a pulmonary and bubonic type. In his account it is noteworthy to observe that he draws attention to the fact that vomiting did not appear to be common at any period of the disease.

Defoe, in his description of the Great Plague of London in 1665, reproduces a regulation which throws some light upon what were probably the leading characters of the outbreak. It runs as follows: 'The master of every house, as soon as anyone in his house complaineth of botch, or purple, or swelling in any part of his body, or falleth other-

wise dangerously sick without apparent cause of some other disease, shall give notice thereof to the examiner of health within two hours after the said sign shall appear.'

Boccaccio, the author, who was an eye-witness of the ravages in Florence (Italy) of an outbreak in the fourteenth century, writes. 'It commenced here with bleeding of the nose, a sure sign of inevitable death. Not only human beings, but animals also, fell sick and shortly expired if they but touched articles belonging to the sick or dead.' He further relates having seen two hogs tearing the clothes of a patient who had died of the plague, after which they staggered about for a while and then fell down dead, as if they had taken poison; and also that, in other places, multitudes of cats, dogs, fowls, and other animals, fell victims to the contagion.

Cleyn relates of an outbreak in Ireland in 1349 that 'many died from carbuncles, and boils, and botches which grew on the legs or under the arms; others from passion of the head, as if thrown into a frenzy; others by vomiting blood.'

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features of former epidemics are rare now, and *vice versâ*. It is not unlikely that terms were somewhat loosely applied to conditions which were not identical, pathologically, with those to which such terms are peculiar now. For example, considering how rare, in recent plague epidemics, has been the complication which we know as carbuncle (so rare, indeed, that the association can hardly be regarded as more than coincidental), it is almost certain that the symptom so called by most of the older writers was not carbuncular at all, but really identical with the blebs or blisters so commonly observed in recent epidemics,* which, after bursting, leave sloughing bases resulting in indolent ulcers. Shafonski's description, indeed, practically proves that such is the case. 'The very first and most decisive external sign of the plague,' he writes, 'is a black boil called a carbuncle (carbunculus, anthrax). It may appear on any part of the body without exception, and always begins with a burning pain, as though the body had been burnt, after which there soon appears at that spot a livid blister, filled with thin fluid. The bladder is at first very small, like an ordinary pimple, but from hour to hour becoming larger and more prominent, and around it the body becomes red; in some it rises in the course of a

day or more, in some a few hours, and then bursts, or the patient himself, lying in a fever, crushes it. As soon as the blister breaks and the fluid escapes, then under the cuticle a black spot, as though burnt, level with the surface of the body, is presented to the eye—in some the size of a poluska [small obsolete coin], and in some as big as the palm of the hand. This sign, which is like a St. Anthony's fire turned into a black and burnt spot, is called, from its blackness, a carbuncle.' (From Clemow's 'Plague Epidemics in Russia ')

There can be no doubt, however, regarding some of the other features. Petechiæ, variously described as maculæ (Hodges), blue spots (Shafonski), eruption (Gibbon), purple (Defoe), and other hæmorrhages—*e.g.*, dysentery and the flux (Josephus), bleeding of the nose (Boccaccio), vomiting and spitting of blood, etc.—appear to have been among the most prominent early characteristics of many of the great historic epidemics, though less common now in the beginning of an attack.

The offensive breath, indicating gangrenous inflammation of the lungs, which we read of as being so common during the outbreaks of the fourteenth century, is seldom associated with the pneumonic variety of plague nowadays Diarrhœa, which,

according to Shafonski, was often the direct cause of death from its severity, has in recent times been scarcely a more common manifestation than the reverse condition, and not particularly severe when present. Vomiting, which occurs in most cases now, is seldom alluded to in descriptions of old epidemics; while one writer (Maclean) expressly mentions that it did not appear to be a common symptom at any period of the epidemic which he describes. Vibices or wheals, as though the body had been beaten, referred to by Shafonski, are practically never seen now.

It would appear that the mortality from plague, as well as its infectivity, used to be much more severe, and the course of an attack much more rapidly fatal than at present. Petrarch, writing of a friend who succumbed, relates that 'he was suddenly seized in the evening by the pestilential sickness. . . . He passed the night bravely in the last agony, and in the morn was carried off by a *swift death. . . . In three days his sons* and all his family had followed him to the tomb.'

Boccaccio writes that 'the plague spread itself with great fury, communicating from the sick to the healthy like fire among dry and oily fuel.'

A priest, who was an eye-witness of an outbreak

at Avignon, refers to the pneumonic variety in the words, 'The contagious nature of the disease is, indeed, the most terrible of all the terrors of the time, for when anyone who is infected with it dies, all who see him in his sickness, or visit him, or do any business with him, or even carry him to the grave, quickly follow him thither, and there is no known means of protection.' Of the bubonic type he writes 'This likewise is quickly fatal. The sickness has already grown to such proportions that, from fear of contagion, no doctor will visit a sick man, even if the invalid would gladly give him everything he possessed; neither does a father visit his son, nor a mother her daughter, nor a friend his friend'

In many old descriptions we read that the consecrated churchyards were unable to contain the dead, and that various devices had therefore to be resorted to in different places. In Vienna corpses were arranged in layers by thousands in pits outside of the city. In London, in one burial-ground alone, over 50,000 corpses were similarly disposed of. The Pope consecrated the Rhone for the rapid disposal of plague corpses by throwing them in.

Hodges, writing of the Great Plague of London (1665), says: 'The disease generally manifests itself

by the usual febrile symptoms of shivering, nausea, headache, and delirium. In some these affections were so mild as to be mistaken for a slight and transient indisposition. The victim saw not, or would not see, the insidious approach of his foe; he applied himself to his usual avocations till a sudden faintness came on, the maculæ, the fatal "tokens," appeared on his breast, and within an hour life was extinct.'

The London mortality bill for the week ending September 19, 1665, records more than 10,000 victims from plague during that week alone, and, owing to inaccuracies in the bills in those days, it was generally acknowledged that they seldom returned more than two-thirds of the real number.

The following regulation is a type of many similar ones issued at various places during different epidemics, and well illustrates the panic caused by the dread of contagion: 'Every plague patient shall be taken out of the city into the fields, there to die or recover. Those who attend upon a plague patient shall remain apart for ten days before they again associate with anybody. The priests shall examine the diseased, and point them out to special commissioners under penalty of a confiscation of their goods, and of being burned alive. Whoever

shall import the plague into a community not previously infected shall have all his goods confiscated, and none shall attend upon plague patients except those appointed for that purpose, on pain of death and confiscation.' (From Bryan's 'Footprints of the World's History.')

In the *Bombay Gazetteer* we read of the plague in India in the seventeenth century, that 'no place in Hindustan was free from its ravages. Lulling at times, it continued to lay waste the country for eight years. About the same time in Kandahar the land was overrun by mice, and mice and plague seem to have had some close connection. A mouse would run out of its hole as if mad, and, striking itself against the doors and walls of the house, would die. Then the plague was in the house. If the people at once fled, they might be saved; if they stayed, the whole village was swept away.'

The plague which spread over the Roman Empire in the sixth century appears to have lasted for over fifty years; and, according to Hecker's estimates, Europe must have lost about a quarter of her total population during the prevalence of the outbreaks known as the Black Death Regarding this particular pestilence, the medical faculty of Paris, which was considered to be the most celebrated body of

physicians in the fourteenth century, was commissioned to deliver an opinion, together with recommendations as to the proper mode of living during its prevalence. The report issued was a most remarkable document, and would bear reproduction here, if only to serve as an illustration of the condition of medical science 600 years ago. It runs as follows:

'We, the members of the College of Physicians of Paris, after mature consideration and consultation on the present mortality, collected the advice of our old masters in the art, and intend to make known the causes of this pestilence more clearly than could be done according to the rules and principles of astrology and natural science. We therefore declare as follows:

'It is known that in India and the vicinity of the Great Sea the constellations which combated the rays of the sun, and the warmth of the heavenly fire, exerted their power especially against that sea, and struggled violently with its waters. Hence, vapours often originate which envelop the sun, and convert his light into darkness. These vapours alternately rose and fell for twenty-eight days; but at last sun and fire acted so powerfully upon the sea that they attracted a great portion of it to

themselves, and the waters of the ocean arose in the form of vapour, thereby the waters were in some parts so corrupted that the fish which they contained died. These corrupted waters, however, the heat of the sun could not consume, neither could other wholesome water, hail or snow, and dew, originate therefrom. On the contrary, this vapour spread itself through the air in many places on the earth, and enveloped them in a fog.

'Such was the case all over Arabia, in a part of India, in Crete, in the plains and valleys of Macedonia, in Hungary, Albania, and Sicily Should the same thing occur in Sardinia, not a man will be left alive; and the like will continue so long as the sun remains in the sign of Leo, on all the islands and adjoining countries to which this corrupted sea wind extends, or has already extended from India. If the inhabitants of those parts do not employ and adhere to the following, or similar, means and precepts, we announce to them inevitable death except the grace of Christ preserve their lives

'We are of opinion that the constellations, with the aid of nature, strive, by virtue of their divine might, to protect and heal the human race; and to this end, in union with the rays of the sun, acting through the power of fire, endeavour to break

through the mist. Accordingly, within the next ten days, and until the seventeenth of the ensuing month of July, this mist will be converted into a stinking, deleterious rain, whereby the air will be much purified. *Now, as soon as this rain announces* itself, every one of you should protect himself from the air; and, as well before as after the rain, kindle a large fire of vine-wood, green laurel, or other green wood; wormwood and camomile should also be burned in large quantities in the market-places, in other densely inhabited localities, and in the houses.

'Until the earth is again completely dry, and for three days afterwards, no one ought to go abroad in the fields. During this time the diet should be simple, and people should be cautious in avoiding exposure in the cool of the evening, at night, and in the morning. Poultry and water-fowl, young pork, old beef, and fat meat in general, should not be eaten; but, on the contrary, meat of proper age, of a warm and dry nature, *by no means, however, heating and* exciting. Broth should be taken seasoned with ground pepper, ginger, and cloves, especially by those who are accustomed to live temperately, and are yet choice in their diet. Sleep in the day time is detrimental; it should be taken at night until

sunrise, or somewhat longer. At breakfast one should drink little; supper should be taken an hour before sunset, when more may be drunk than in the morning. Clear, light wine, mixed with a fifth or sixth part of water, should be used as a beverage. Dried or fresh fruits with wine are not injurious, but highly so without it. Beetroot and other vegetables, whether eaten pickled or fresh, are hurtful, on the contrary, spicy pot-herbs, as sage and rosemary, are wholesome. Cold, moist, watery food is, in general, prejudicial. Going out at night, and even until three o'clock in the morning, is dangerous, on account of the dew. Only small river fish should be used. Too much exercise is hurtful. The body should be kept warmer than usual, and thus protected from moisture and cold. Rain-water must not be employed in cooking, and everyone should guard against exposure to wet weather. If it rain, a little fine treacle should be taken after dinner. Fat people should not sit in the sunshine. Good clear wine should be selected and drunk often, but in small quantities, by day. Olive-oil as an article of food is fatal. Equally injurious are fasting or excessive abstemiousness, anxiety of mind, anger, and excessive drinking. Young people, in autumn especially, must abstain

from all these things, if they do not wish to run a risk of dying of dysentery. In order to keep the body properly open, an enema, or some other simple means, should be employed when necessary. Bathing is injurious. Men must preserve chastity as they value their lives. Everyone should impress this on his recollection, but especially those who reside on the coast, or upon an island into which the noxious wind has penetrated.' (From Bryan's 'Footprints of the World's History.')

With such ignorance and superstition characterizing men of distinction, and with a reputation for learning, it is not difficult to conceive what effect the horrors of the Black Death must have had over the common people; the religious fanaticism and intolerance which seized whole nations undoubtedly seriously affected the progress of civilization for centuries after.

CHAPTER II

BACTERIOLOGY

General characters of the plague bacillus—Microscopical appearances from (*a*) agar-agar cultures, (*b*) gelatine cultures, (*c*) bouillon cultures—Naked-eye appearances of (*a*) agar-agar cultures, (*b*) gelatine cultures, and (*c*) bouillon cultures—Circumstances favourable to the vitality and virulence of the bacillus—Circumstances unfavourable to its vitality—Susceptible animals—Period of survival, under particular circumstances, of the bacillus—Methods of its entrance into, and exit from, the bodies of men and animals

The varying groups of manifestations which are included under the general term 'plague' depend for their inception and development upon the presence in the organism of a specific infective agent. It is now established beyond doubt that this agent is identical with the bacillus which was discovered by Kitasato, and, independently, by Yersin in 1894.

From the fact that investigators, generally, have failed to establish the presence of this micro-organism

in a saprophytic condition in the outside world, though Yersin claims to have isolated it from earth floors by Calmette's method, and Hankin found it in some salt water in a field near Sewri (Bombay), the view has been more or less generally held that the sources of infection are the products of the disease in recently infected men and animals, such as pus, sputa, blood from hæmorrhages, and contents of blebs; some of their secretions and excretions, such as mucus, saliva, urine, and fæces; and personal effects, such as bedding, clothing, etc.

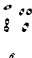
The continued prevalence of plague, however, in certain districts, and its periodical reappearance, with undiminished or increased violence, in particular houses, has led more recent observers to infer that the virus does maintain a separate saprophytic existence. This inference is strengthened by experimental proof that, when artificially introduced, it is capable of survival for a considerable period in sterilized samples of the materials of which the floors of most native houses in India are composed; the failure to isolate it under conditions which obtain in Nature not justifying negative conclusions, but being due to the fact that no reliable method has been discovered for its isolation when in company with myriads of contaminating organisms.

Plate II



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6



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degree, either natural or acquired immunity. It is not motile, possesses no flagella, and its multiplication is independent of spore formation. Staining is readily effected by ordinary basic aniline dyes, the poles generally retaining the stain, and a vacuole being left centrally (Diagram 6), or laterally (Diagram 7). It is characteristic that it does not retain the stain when treated with Gram's process, unless, as pointed out by the Indian Plague Commission,* weakened (50 per cent.) spirit is employed in lieu of absolute alcohol in the decolorization process.

Like other pathogenic organisms, it is capable of luxuriant growth and proliferation on artificial media, the most suitable being agar-agar, gelatine, or bouillon; but, unlike them, it exhibits this characteristic best at low temperatures, the optimum being between 85° and 95° F., though satisfactory growth occurs at much lower temperatures. The Austrian Plague Commission† were able to produce a certain amount of growth at a temperature as high as 107° F. Neutrality or alkalinity of the media are factors which favour its artificial cultivation. When cultivated it exhibits somewhat dif-

* 'Indian Plague Commission Report,' chap. iii., p. 55.

† 'Austrian Plague Commission Report,' part ii., C., p. 630.

ferent microscopical appearances from those above described. These, moreover, vary according, not only to the particular medium employed, but also as to whether the bacilli are from cultures recently *derived from the animal organism, or from such as* have been cultivated on artificial media for several successive generations.

MICROSCOPICAL APPEARANCES OF PLAGUE BACILLI FROM ARTIFICIAL CULTURES.

(a) AGAR-AGAR CULTURES.

Plague bacilli from agar cultures are generally isolated, and, if the result of several successive growths, show little or no vacuolation when stained. In cultures some days old, mixed with typical forms, are found involution forms, characteristic ones being more commonly found in recent cultures from animals than after several successive growths in the laboratory. Such may be elongated, spindle-shaped, dumb-bell-shaped, angular, irregular like amœbæ, lemon or pear-shaped, or branching (Diagrams 8, 9, 10, and 11). They revert to typical forms when freshly cultivated on pure agar. Hankin* has demonstrated that exaggerated types of these

* Evidence before Indian Plague Commission, *vide* chap. iii., p. 59 of Report.

involution forms can be produced by cultivation on agar containing from 2½ to 3½ per cent. of common salt. This is of importance for diagnostic purposes, as the phenomenon appears to be peculiar to the plague bacillus, and not common to pathogenic micro-organisms. The irregular forms observed among bacilli taken direct from the animal organism may be of the same nature as involution forms, but are more probably the result of post-mortem changes.

(*b*) GELATINE CULTURES.

The chief microscopical characteristic observed among bacilli from gelatine cultures is the appearance, among single and diplococcal forms, of filamentous forms, generally without transverse septa (Diagram 12). Klein* has demonstrated that some gelatine colonies produce only filamentous forms, and considers this to be of importance for diagnostic purposes.

(*c*) BOUILLON CULTURES.

Involution forms are not seen among bacilli from bouillon cultures: but, though single and diplococcal forms are present, a streptococcal tendency exists,

* *Vide* chap. iii., p. 58, of 'Report of Indian Plague Commission.'

the chains seldom, however, containing more than six organisms (Diagram 13).

NAKED-EYE APPEARANCES OF ARTIFICIAL PLAGUE CULTURES.

(α) AGAR-AGAR CULTURES

The naked-eye appearances of plague cultivations on agar vary according to the age of the culture. The growth being rapid, colonies develop along the track of the needle within forty-eight hours Some of these grow more rapidly and to a larger size than others. They present irregular margins, and are very sticky, especially in the case of recent cultures from animals. On dry agar, if the material has been spread evenly over the surface of the slant, colonies appear in the form of minute grey specks, with translucent margins, which give, when viewed by reflected light, a ground-glass appearance (Diagram 14); these colonies increase in size, and at a later stage appear as a nucleus surrounded by concentric rings (Diagram 15).

PLATE V



15

(magnified four diameters)

adhere to the sides of the containing vessel, but soon become detached. Haffkine* has demonstrated that, if ghee or oil be added to the bouillon, the colonies grow in the form of tapering stalactites from the drops of oil floating on the surface If the vessel be slightly shaken, these colonies become detached, and fall to the bottom like flakes of snow, and on placing the vessel at rest fresh colonies grow in the same way from the drops of oil This characteristic he considers to be absolutely diagnostic of plague. Hankin* has succeeded in obtaining stalactite growth with other than plague bacilli, but the tapering colonies were very strong, and offered considerable resistance when the vessel was shaken.

Neither in agar nor in any solid medium does liquefaction occur, and, unless protected from circumstances which favour desiccation by such methods as keeping cultures in a moderately cool and dark place, and having rubber caps over the mouths of the containing vessels or tubes, the bacilli die out in a few days; but with these precautions they may survive for weeks or months, and in some cases for over a year.

* Evidence before Indian Plague Commission, *vide* chap. iii., pp. 59 and 60 of Report.

(*b*) GELATINE CULTURES.

Colonies on gelatine, resembling those on dry agar, become visible to the naked eye on about the third day. The centres are opaque and yellowish, and the peripheries translucent, with irregularly crenate borders. They protrude from the surface of the medium, and, as in agar, differ in their rate of growth. Deep colonies take longer to develop than surface ones. In streak cultures the colonies, according to Klein,* somewhat resemble the growth in diphtheria, appearing in the form of a white band, increasing in thickness, and showing an irregularly knobbed margin. In stab cultures a thin white streak appears along the track of the needle, which does not increase in thickness, but the growth may spread as a film over the surface of the gelatine, and after some weeks filamentous outgrowths may occur from the stab, which, when present, are more abundant in the upper than the lower part.

(*c*) BOUILLON CULTURES.

The earliest naked-eye appearance of growth in a bouillon culture is generally that of a collection of floccular masses on the surface. These at first

* *Vide* 'The Bombay Plague,' part ii, chap. iii., p. 122.

adhere to the sides of the containing vessel, but soon become detached. Haffkine* has demonstrated that, if ghee or oil be added to the bouillon, the colonies grow in the form of tapering stalactites from the drops of oil floating on the surface If the vessel be slightly shaken, these colonies become detached, and fall to the bottom like flakes of snow, and on placing the vessel at rest fresh colonies grow in the same way from the drops of oil. This characteristic he considers to be absolutely diagnostic of plague. Hankin* has succeeded in obtaining stalactite growth with other than plague bacilli, but the tapering colonies were very strong, and offered considerable resistance when the vessel was shaken.

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* Evidence before Indian Plague Commission, *vide* chap. iii, pp. 59 and 60 of Report.

CIRCUMSTANCES WHICH ARE FAVOURABLE TO THE VITALITY AND VIRULENCE OF PLAGUE BACILLI.

The vitality of the organism is not generally affected by exposure to extreme cold, and the investigations of the Austrian Commission* prove that its virulence, which is diminished by growth at a temperature corresponding to blood-heat, is not affected by growth at very low temperatures, either on ordinary agar or on that medium with the addition of such chemicals as caustic soda (up to 2 per cent.), grape-sugar, (up to 3 per cent.), and hydrochloric acid (up to 7 per cent.).

From the observations of the Indian† and Austrian‡ Plague Commissions, Klein,§ Hankin,‖ Balfour Stewart,¶ and others, relative to the effects upon its virulence of its passage through several animals of any particular species susceptible to

* 'Report of Austrian Plague Commission,' part ii., C., p. 747.

† 'Report of Indian Plague Commission,' chap. iii, p. 57.

‡ 'Report of Austrian Plague Commission,' part ii., C., p. 767, table 20.

§ *Vide* 'The Bombay Plague,' part ii., chap. iii., p. 120.

‖ Evidence before Indian Plague Commission, *vide* chap. iii., p. 57 of Report.

¶ *British Medical Journal*, September 2, 1889.

plague, it would appear that an exaltation takes place in the case of mice and rabbits, but a diminution in the case of rats, whether or not intercalation of cultivation on artificial media between the passages is effected.

Artificially introduced into moist sterilized cow-dung, it retains its vitality for a very considerable period, and from this it may be inferred that the materials composing the floors of native houses afford ample pabulum for its development. This inference receives confirmation in the discovery by Marsh* that particularly luxuriant growth takes place in agar cultures if buried beneath such floors—a phenomenon which he considers to be chiefly due to the large proportion of carbonic acid gas in the ground air.

Circumstances which promote its growth and development are also active in effecting resuscitation in the case of attenuated specimens. Batzaroff† succeeded in producing a fatal type of plague by placing upon the nasal mucous membrane of the guinea-pig specimens of plague bacilli which had become attenuated, and which had failed to cause

* Evidence before Indian Plague Commission, *vide* chap. iii., p. 64 of Report.

† *Annales de l'Institut Pasteur*, 25 Mai, 1899, pp. 391, 392.

any more than a slight reaction when inoculated in large quantities under the skins of these animals, or into the subcutaneous tissues of mice and rats Professor Fraser* *suggests, in explanation of this,* that the excess of carbonic acid gas to which the organisms were subjected at each expiration probably enhanced their noxious qualities, just as that in the ground air augmented their proliferation in Marsh's experiment. This explanation may also *account for the extreme virulence of the type of* plague which it is believed can be contracted by inhalation of the virus from patients with primary plague pneumonia, or from contact with the products of the disease in them; also for the fact that virulent bacilli continue to be thrown off in their sputa for long periods after the establishment of convalescence.

CIRCUMSTANCES WHICH ARE UNFAVOURABLE TO THE VITALITY OF PLAGUE BACILLI.

Among the agencies which exert a deleterious influence upon the organism are heat, circumstances which favour desiccation, light, efficient ventilation, and chemical disinfectants

* Appendix iii. of 'Report of Indian Plague Commission,' p. 482.

As it is incapable of resisting exposure to any temperature above 70° C., it is readily killed by boiling or the action of saturated steam under pressure.

Desiccation devitalizes it in direct proportion to the extent of exposure to dry heat (either artificial or from the direct rays of the sun), and to free ventilation.

As regards chemical disinfectants, while it exhibits considerable resistance to the action of reducing agents and alkalies, it is readily destroyed by oxidizing agents and acids (the inorganic being more active than the organic acids).

Serum from plague patients, at any time after the first week of their illness, appears to exert an inhibitory effect upon its growth in artificial media.

SUSCEPTIBLE ANIMALS.

Besides human beings, rats, squirrels, mice, and monkeys are very susceptible to plague; also rabbits, cats, and guinea-pigs if kept in confinement. From recent experiments in China Dr. Simpson* has demonstrated that calves, buffaloes, pigs, and poultry are also susceptible, and he considers that the

* *British Medical Journal*, March 28, 1903, p 756.

endemicity of the disease in places where the inhabitants *live in close association with such animals* may be explicable on the grounds that domestic animals suffer from chronic as well as acute plague.

Certain insects, such as ants, flies, bugs, and fleas, which are parasitic to infected or dead animals, may also become carriers of infection. Giuseppe Zirolia* has recently discovered that fleas, after sucking the blood of infected mice, retain bacilli alive and active for seven or eight days, and that the bacilli are capable of multiplying in the fleas' bodies (p. 41).

PERIOD OF SURVIVAL OF PLAGUE BACILLI UNDER PARTICULAR CIRCUMSTANCES.

The organism has been found active in grain and articles of merchandise under varying circumstances. Its period of survival therein is generally limited, and depends, except, perhaps, in the case of food, less upon chemical than mechanical conditions, being longer in porous than non-porous materials, either on account of their moisture-retaining qualities, or because of difficulty of access of drying influences.

From common tap-water, according to the German

* *Centralblatt für Bakteriologie, Parasitenkunde und Infektionskrankheiten*, vol. xxxi., No. 14, for June 3, 1902.

Plague Commission,* it cannot be recovered when artificially introduced after the fifth day, or from sterilized tap-water after the tenth day.

Under ordinary atmospheric conditions in the dry season in Bombay, if artificially introduced into any fabric it dies within a week; at lower temperatures, even when exposed to desiccating factors, it is capable of surviving for considerable periods. Forster, Loffler, and Gladin† recovered it from silk, wool, and cotton respectively after forty-five, fifty-six, and seventy-six days' exposure, under atmospheric conditions, to a temperature ranging from 18° to 25° C The Indian Plague Commission‡ recovered it, under similar conditions, after seventy days, and the German Plague Commission§ after twenty-eight days

METHODS OF ENTRANCE INTO, AND EXIT FROM, THE BODIES OF MEN AND ANIMALS OF THE PLAGUE BACILLUS.

All observers are agreed that the bacillus effects an entrance into the bodies of men and animals

* From 'Report of German Plague Commission,' quoted in 'The Bombay Plague,' part ii, chap. iii., p 122.

† *Centralblatt fur Bakteriologie, Parasitenkunde und Infektionskrankheiten*, December 28, 1899, p. 722.

‡ 'Report of Indian Plague Commission,' chap. vi., p. 364.

§ 'Report of German Plague Commission,' p 277.

either through the skin or mucous membrane. Although the point of entrance has in rare cases been localized in the conjunctiva and genito-urinary passages, and experimenters have succeeded in *inoculating animals through the gastro-intestinal* tract, by far the commonest natural methods of entrance are by the skin, through some (though often imperceptible) solution of continuity, and by the respiratory passages, either by direct inhalation into the lungs, or by extension of inflammation from a seat of inoculation in the buccal or nasal mucous membrane.

After effecting an entrance, in most fatal cases, and also in many cases which recover, the bacillus enters the blood-stream, and can thus invade any part of the body; in post-mortem examinations, therefore, *it may be found in any of the viscera*, as well as in the blood and in the contents of buboes. Without getting into the blood-stream, it may be found in mucus or some secretion, when the point of entrance is on a mucous surface, or by a back-flow of lymph *from the affected glands*

The bacillus leaves the body by some of the secretions or excretions; by its own products, such as débris from disintegrating buboes, contents of blebs or other skin eruptions, sputa, etc.; or in blood by hæmorrhages from any part.

In uncomplicated cases, therefore, in which the bacillus does not primarily gain entrance by the blood-stream, respiratory apparatus, or any mucous surface, the chances of its leaving the body are practically limited to its escape in the débris from disintegrating buboes, in rare cases in the pus from suppurating buboes, and in the contents of the bleb which sometimes marks the point of inoculation. A more detailed consideration of the modes of infection will be found in the following chapter under the heading of Exciting Causes

CHAPTER III

ÆTIOLOGY

A. Predisposing causes: (a) Epidemiological considerations —Plague infectivity between animals and human beings—Infectivity of infected clothing or other personal effects —Infectivity of merchandise—Infectivity of houses; (b) Circumstances affecting the liability of the individual —Influence of age—Influence of sex—Influence of race—Influence of occupation—Influence of temperament—Influence of heredity, (c) Influence of environment—Climate—Locality—Hygienic conditions—B. Exciting causes, giving details of mode of infection.

THE infectivity in certain epidemiological relationships of *Kitasato's bacillus, together with particular* circumstances having reference to the individual and his environment, comprise a group of factors which may be considered to be the predisposing causes of plague; while the entrance into the body of that organism constitutes the proximate or exciting cause of the phenomena which determine the presence of the malady.

A. PREDISPOSING CAUSES

(*a*) The epidemiological considerations which have an ætiological bearing refer to facts in connection with plague infectivity as between human beings, between animals and human beings, by clothing or other personal effects, by merchandise, and by houses.

(*b*) The circumstances affecting the liability of the individual include such factors as age, sex, race (so far as it affects habit), occupation, temperament, and heredity.

(*c*) Under the term 'environment' may be considered the influence of climate, locality, and hygienic conditions generally.

(*a*) EPIDEMIOLOGICAL CONSIDERATIONS.

Plague Infectivity between Human Beings.—The extent to which this factor is operative in individual cases is necessarily in direct proportion to the degree of opportunity afforded for the escape from the infected body of the infective agent. As has been seen, the chances of escape are limited in cases in which the organism has not entered the blood-stream, or has not infected the respiratory passages, or has not, in primary bubonic cases, gained

entrance by a mucous surface. Thus, ordinary uncomplicated bubonic cases resulting from skin inoculation are only infective to a slight extent; while the so-called septicæmic cases, pneumonic cases, and uncomplicated bubonic cases in which the point of inoculation is on a mucous surface, are so in a much higher degree.

Taking plague cases, generally, in such conditions as obtain in good houses, or places like plague hospitals, where circumstances favouring desiccation are encouraged, chemical disinfectants freely used, and other precautions adopted, the factor does not play an important part in the spread of plague; but the reverse is the case when the escape of the virus takes place under circumstances which are favourable for the preservation of its vitality. As, moreover, such escape may continue to occur for long periods after the establishment of convalescence, as demonstrated by Cayley,* Gotschlich,† and others, it is not difficult to estimate how important a focus of infection even one case may become under suitable circumstances

It is apt to be considered that rapidly fatal cases,

* Evidence before Indian Plague Commission, *vide* chap. iii., p. 92 *of Report.*

† *Zeitschrift für Hygiene*, 1899, p. 405.

though of highly infectious types, do not contribute in an important degree to the spread; but it must not be overlooked that enormous numbers of bacilli may escape from such, before death, into surroundings calculated to preserve their vitality and promote their proliferation.

Plague Infectivity between Animals and Human Beings.—As plague bacilli escape from the bodies of animals in the same way as from those of men, there can be no reasonable doubt that animals may also act as agents of dissemination Of all susceptible animals, rats are naturally the most important agency in this factor, because of their living in houses, in close proximity to men, and especially in those parts of houses in which the conditions are favourable for the preservation of the liberated virus. Although, individually, they are not as important as individual human beings as foci of infection; taken as a whole, they cannot be considered to fall short in importance, seeing that so many more of them than of human beings contract the disease. Many eminent authorities, including Koch,* hold the view that plague is primarily an epizootic, and that epidemics among men are

* Address before the German Society of Public Health, *vide British Medical Journal*, July, 1898.

entrance by a mucous surface. Thus, ordinary uncomplicated bubonic cases resulting from skin inoculation are only infective to a slight extent; while the so-called septicæmic cases, pneumonic cases, and uncomplicated bubonic cases in which the point of inoculation is on a mucous surface, are so in a much higher degree.

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It is apt to be considered that rapidly fatal cases,

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from infected food, are agencies of some importance, especially birds and domestic animals, such as dogs.

Suctorial and parasitic insects, as well as ants and flies, may also be carriers of plague bacilli; Giuseppe Zirolia* of Rome has observed that a flea which has been starved for a time, after sucking the blood of an animal, projects (without withdrawing its proboscis) a stream of blood by abdominal contraction to wash out its duct before sucking afresh, as he has also demonstrated (p. 32) that plague bacilli may remain alive and virulent in fleas for several days, it may come to be established that fleas are 'middlemen' of infection between rats or mice and human beings. It has yet to be demonstrated, however, that rat fleas are also parasitic to human beings.

Infectivity of Infected Clothing or other Personal Effects.—There are numerous instances on record which demonstrate that the importation of infected clothing by people (themselves not infected) has given rise to epidemics in uninfected places, starting by rats becoming infected in the houses into which the infected clothing had first been introduced

Besides such particular instances, it has been

* *Centralblatt für Bakteriologie, Parasitenkunde und Infektionskrankheiten*, vol. xxxi., No. 14, for June 3, 1902.

secondary to, and dependent upon, primary epizootics among rats. Whether this be so or not, there is ample evidence to show that, in individual localities, outbreaks among men have frequently followed those among rats, and that where infection has been clearly traced to the importation of infected clothing into uninfected villages, the epidemics following have been started by rats. It is unlikely that they become, as is supposed, carriers of infection for considerable distances by migrating from infected to uninfected areas, except, perhaps, in the case of seaport towns becoming infected by ship-borne rats from distant ports. But it is highly probable that one part of a town may be infected, by their agency, from another, or a village from a very adjacent one

Mice and squirrels rank next in importance to rats as agencies in this factor, but in a much lower degree. Their influence has, however, in some places operated to a sufficient extent to indicate that it should not be overlooked.

Of other susceptible animals, none may be said to be of particular importance in this connection; but carnivorous animals, which, though not themselves susceptible, may become carriers of infection by leaving about parts of the bodies of infected animals, or by the presence in their excreta of plague bacilli

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common experience that plague has continued to occur among people after evacuation from infected villages or towns in cases in which their effects had not first been disinfected, and has ceased to occur after thorough and wholesale disinfection.

It is also apparent, as far as railway traffic is concerned, that infection is carried less in the persons of travellers than in their effects, seeing that though the spread occurs chiefly along the railway routes, the numbers of cases detected at inspection posts have been very small in comparison with the numbers of persons travelling.

There can, therefore, be no doubt that this is a powerful factor in plague dissemination, especially as fabrics of a porous texture folded away in boxes or bags may retain the infection for a very considerable time on account of difficulty of access of desiccating factors. It is true that experimental attempts to isolate the virus from probably infected clothing has been attended with practically uniformly negative results; but this is in all probability due to its association with contaminating micro-organisms rendering its separation very difficult by any known method. *Artificially introduced on to any fabric,* and exposed to the ordinary atmospheric conditions obtaining in Bombay in the dry season, it dies

within a week by the influence of desiccation At lower temperatures, however, even when exposed to desiccating factors, it is capable of surviving for considerable periods As has been seen,* Forster, Loffler, and Gladin recovered it from silk, wool, and cotton respectively after forty-five, fifty-six, and seventy-six days' exposure, under ordinary atmospheric conditions, to a temperature of from 18° to 25° C The *Indian Plague Commission* recovered it, under similar conditions, after seventy days, and the German Plague Commission after twenty-eight days.

Infectivity of Merchandise.—It is improbable that merchandise, in the ordinary acceptation of the term, acts as an important factor in the dissemination of plague. It can only become infected itself by direct contact with the virus, and this is, obviously, most unlikely, except, perhaps, in the case of grain and food stuffs stored in places to which rats have free access. Evidence, moreover, of the spread of plague by grain or other food is scanty and inconclusive, and when artificially introduced the virus rapidly dies in such articles; but the possibility of their being infective, even for a short time, must not be disregarded, and the importation of them from infected to uninfected places should be looked

* *Vide* Chapter II., p. 33.

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revealed the existence of many places, not only which it is impossible for disinfectants to reach, but upon which desiccating factors cannot by any contrivance be brought to bear. When the tenants of these dwellings—who in fair weather sleep in the open—are driven by rain or cold to sleep inside, the addition of many factors accrues which, if they do not immediately arouse the germs to activity, favour their growth and proliferation and enhance their virulence. Amongst the foremost of these are the warmth radiated from the bodies of the occupants, the moisture in the air inseparable from an aggregation of living creatures, and excess of carbonic acid gas from their combined exhalations. The continued action of such factors, for a time, doubtless renders the virus extremely infective, and the house in which it is contained a dangerous focus of infection in its locality—all the more important because of the probability of a rapid outflow of infection in every direction by infected rats being driven from their holes, and seeking shelter in neighbouring dwellings.

Professor Fraser* considers it to be completely established that the insanitary conditions existing

* Appendix iii. to 'Report of Indian Plague Commission,' p. 484.

upon as possessing a certain degree of ætiological significance.

In some places outbreaks appear to have started among traders, and spread from their places of business; and many have considered that this indicates that infection is commonly contracted from merchandise.

If traders, however, show any superior liability to become affected, the explanation more probably, as suggested by the Indian Plague Commission,* lies in the facts that, as they travel more than others, they are more likely to visit infected places; that they are, by reason of their occupation, brought more than others into contact with large numbers of people, many of whom may be infected; and that, if dealing in grain, their places are more likely to be the earliest infected by rats attracted thereto for food.

Infectivity of Houses.—The periodical recurrence of plague under certain circumstances in particular houses, notwithstanding the free use of disinfectants therein, points, as has already been suggested, to the very probable existence of the virus as a saprophyte in the floors or other parts of such houses. Detailed examination of a large number of them has

* 'Report of Indian Plague Commission,' chap. III., p. 140.

young and old, among whom concealment, being more readily effected, is more commonly practised than among the middle-aged.

Even were it possible to obtain an accurate record of the total number of cases in any community, in each age group, the exodus which invariably follows the introduction of infection into a place would render any attempt to draw correct ratios between these numbers and the total census population in each group futile.

Middle-aged and elderly people, in consequence of immunity acquired by attacks in early childhood, are generally proof against the invasion of such other specific diseases as the exanthemata, pertussis, etc , but not possessing such immunity in the case of plague, as it is not ever-present, and therefore not a disease of the young chiefly, they are as liable to be attacked as younger persons, and probably with much greater frequency, owing to the increased liability which comes with advancing age to contract diseases characterized by nervous and physical depression.

Influence of Sex.—There is no reliable evidence to indicate that one sex is more susceptible to plague than the other, and it is impossible, for the reasons given above, to form even an approximately accurate

in the majority of native houses have exerted a direct and important influence, 'which is indeed a preponderating one,' upon the extent and fatality of the epidemic which has been prevailing in India.

The Indian Plague Commission* state that 'the universal experience of plague in India proves that houses into which the infection of plague has been imported, whether by men or rats, are infective, their infectivity being so marked that many of the officers who have had most experience of the disease have come to the conclusion that the principal source of infection is, as would appear to hold true in the case of yellow fever, and possibly also of typhus, to be found in the houses into which the infection of plague has been introduced.'

(b) CIRCUMSTANCES AFFECTING THE LIABILITY OF THE INDIVIDUAL.

Influence of Age.—It is impossible to adjudge from available statistics whether persons are more liable to be attacked by plague at any particular period of their lives than at others, not only because such statistics are incomplete as a whole, but because they are more particularly so with regard to the

* 'Report of the Indian Plague Commission,' chap. iii., p. 101.

It* is also true that the mortality from typhus, which even in non-epidemic years was over 300 per 1,000,000 in London, is now only 1 per 1,000,000, and that that from typhoid fever has within the past thirty years decreased by over 50 per cent.

It is also true that the annual death-rate in London, which now is less than 20 per 1,000, was as high as 80 per 1,000 four centuries ago, though the population then was less than one-twentieth of what it is now; and that this improvement means not only that millions of cases of disease have been prevented, but that there has been a saving of millions of lives, and that a much larger number of people reach old age in England now than was formerly the case.

It is also true that this reduction in mortality, mitigation of suffering, and increased longevity, are merely some of the triumphs of practical sanitation. Other triumphs have been achieved thereby, but among these one of the most important is the effect which it has exercised in educating the minds of the people in the principles of hygiene. It is this that has brought about the improvement in habits and customs which causes those nations who recognise the deleterious influence of insanitary conditions

* Statistics from *Journal of State Medicine*, 1897.

conclusion in this connection from available statistics. There is, moreover, no reason to suppose that any extra liability to contract a disease of this nature exists in either sex, except, perhaps, such a purely accidental one as that suggested by the Indian Plague Commission,* in accounting for a probable higher incidence among women than men, viz., that 'by reason of their more confined life women would more than men be exposed to the risk of contracting the disease from the infection lurking in infected houses.'

Influence of Race.—Saving in so far as it affects habit and custom, there is nothing in the history of the past, or, indeed, of the recent epidemics, to warrant the assumption that race has any influence upon individual liability to plague.

It is true that during the recent epidemics the incidence among Europeans has been infinitesimal as compared with that among the natives of India and China, and that, though imported into several European ports, plague has failed to establish itself in an epidemic form at any of them.

But it is also true that in London, in the seventeenth century, over 10,000 deaths from plague were reported in a single week.

* 'Report of Indian Plague Commission,' chap. ii, p. 138.

be necessary to complete the predisposition, seeing that attendants in hospitals who are exposed to them enjoy a singular immunity, as do also scavengers and washermen who work in the open and live under good hygienic conditions, while there is evidence to show that those of the latter classes whose work and habitation are amid imperfect surroundings are peculiarly liable to contract the infection, as are also those who, under similar conditions, prepare corpses for funerals or deal with the clothing of plague cases.

Persons exposed to the fourth agency, such as disinfectors, exhibit a marked tendency to become infected as the result of their occupation; and the last two naturally predispose all who are, by reason of their calling, exposed to them; the possibility of wounds giving importance to the first, and the directness of the second rendering it one of those predisposing causes between which and an exciting cause it is very difficult to draw a line.

Influence of Temperament.—The predisposition to contract other specific disorders which is believed to exist among persons of a nervous temperament may also render such individuals liable to contract plague; and they are, as a rule, more likely than others to suffer from delirium and brain complications.

upon public health to adopt a more perfect environment than those who do not, and than their own forefathers who lived in pre-hygienic days.

The so-called racial immunity, therefore, which has been enjoyed by Europeans and those who live like them, is only 'racial' to the extent that it depends on the gradual improvement in environment which nearly a century of organized sanitation has succeeded in effecting.

Influence of Occupation.—Occupations which predispose to disease, generally, may also predispose to plague, more especially those which entail exposure to imperfect hygienic conditions, or necessitate the inhalation of impure air in overcrowded factories, or reduce the vital powers by involving exposure and irregular food-supply. But there are occupations which it has been found have a direct bearing upon the causation of plague, and these obviously include such as bring individuals constantly into contact with the liberated virus, either in clothing, excretions, secretions, infected dwellings, tissues (as in post-mortem examinations), or exhalations from, or the products of the disease in, patients suffering from primary plague pneumonia

In the case of the first three of these agencies, the association of insanitary conditions would appear to

(c) INFLUENCE OF ENVIRONMENT.

Climate.—Apart from the effects of climatic causes in generally predisposing to disease, the influence of this factor in plague causation lies chiefly in the extent to which the habits of the people are modified by its incidence Cold and wet drive those who generally sleep in the open to sleep in houses, in many of which the plague virus may exist in saprophytic form. This gives rise to factors which, as has been seen, render the germs infective, and a source of great danger, not only to the tenants, but also to the neighbours

It does not appear to play any part at all in directly influencing plague incidence, as it is well known that plague epidemics occur with equal severity during Northern winters as during tropical summers It exercises, however, an indirect influence in modifying the severity of epidemics, as, for example, when excessive heat compels people to live much and sleep in the open, an epidemic begins to decline; or, on the other hand, when continuous heavy rains fall an epidemic increases in severity, not only because of the exposure of people to the virus in infected houses, but because of the impos-

Those of a sanguine temperament, though not especially predisposed, show a marked tendency to hæmorrhages if they happen to become affected.

The form of individual idiosyncrasy which is known to render those possessing it liable to contract any infection to which they may be exposed acts, in all probability, in them as a predisposing cause of plague. It is supposed that amongst these one attack of a specific disease does not always confer immunity against future attacks, and it may be the influence of this particular idiosyncrasy which has operated in the instances which have been recorded of individuals who have suffered more than once from plague, it being practically established that, as in other specific diseases, one attack of plague protects against future attacks.

Influence of Heredity.—The fact should be borne in mind, as of ætiological significance in plague, that there is evidence to show that predisposition to contract specific diseases, generally, can be transmitted from parent to offspring. In the case of plague, therefore, some form of prophylaxis would appear to be particularly called for in individuals or families in which there is a history of this tendency, especially during the course of an epidemic.

infectivity of houses, which, as has been seen, is so important a factor that most observers regard it as the principal source of infection.

It is most probable that rural houses are less likely to become infective than suburban ones, and these, in their turn, than urban ones, especially in India, where urban sanitation is either totally neglected, or only in its infancy; but the extent to which this agency predisposes urban, suburban, or rural communities to plague depends upon many qualifying circumstances

It would at first sight appear that plague incidence would be greater among urban communities than the others, because of density of population exposing more individuals to infection, but overcrowding, *per se*, does not render infected houses infective, it is necessary that it should cause conditions favourable to the proliferation of the virus, and such do not accrue unless it is associated with deficient ventilation and certain other factors. Villagers are more apt than townsfolk to shut out air from their dwellings; fewer people, therefore, might constitute technical overcrowding in rural than in urban houses On the other hand, rural communities are less predisposed, generally, to disease than urban ones; and this may modify any

sibility of carrying out plague measures, such as *disinfection, evacuation, etc.*

The factor may, further, predispose the inmates of infected houses to plague by the influence upon them *of the escape of noxious volatile gases from the* ground, which, as pointed out by Professor Hunter Stewart,* takes place when the temperature of *the subsoil air, at a depth of 5 feet, is higher than* that of the atmosphere, by the weight of the latter causing the former to escape at points of least resistance, such as the *floors* of native houses, especially at night, when the inside air is warm, and that without very cold and therefore heavy.

Locality.—It can be safely asserted that *geological* formation has no effect whatever upon plague incidence; nor does it play any part in predisposing the individual, beyond the *effect exercised by certain* soils (such as those which are water-logged, or contain excess of vegetable matter, or from which *organic emanations are abundant) in predisposing* to disease.

Notwithstanding this, it is generally admitted *that* plague is essentially a disease of locality. This peculiarity must therefore depend upon the

* 'Report of Indian Plague Commission,' chap. iii., pp 156, 157.

places Such conditions include, chiefly, the form of overcrowding which causes air pollution and excess of carbonic acid gas, either by deficient ventilation, absence of ventilation, or ventilation with air contaminated by outside filth; darkness due to faulty construction of dwellings or other causes, moisture generated by an aggregation of human beings, and retained by difficulty or impossibility of the access of desiccating factors; and air pollution by noxious emanations from soil or organic filth. They are brought about, as has been seen, by persons who habitually sleep in the open being driven to sleep within their houses by cold or rain, and neglecting to clean their rooms before sleeping therein, or to ventilate them while doing so; and they result in favouring the growth and proliferation of the virus, which would, by the application of simple hygienic rules and principles, remain harmless, become attenuated, or die out altogether

It is not difficult to understand, therefore, that faulty hygienic conditions within houses predispose very powerfully to plague, and, for obvious reasons, this factor exerts its influence upon the individual to a greater extent by night than by day.

special predisposition to plague caused by technical overcrowding in infected houses.

Whether this be so or not, as far as India is concerned, plague incidence does not appear to be less in infected villages than in infected towns; but houses in particular localities, either in towns, suburbs, or villages, seem more liable than those in other localities to retain the infection, and periodically to become highly infective, in spite of all preventive measures short of total demolition (the only remedy).

Hygienic Conditions.—As seasonal and meteorological conditions, altitude, latitude, climatic incidence, or geological formation, exert no direct influence which can account for the fact that plague may assume epidemic proportions at all times of the year, and during one season at one place, and another at another—as, moreover, it is well established that houses retain infection and become under certain insanitary conditions highly infective—it is reasonable to suppose that the so-called cyclical or seasonal incidence may be explained by the fact that conditions favourable for rendering infected houses infective (which could be brought to bear, within such houses, at any time of the year) recur, naturally, at different times of the year in different

buboes are found with greater or less frequency in the various regions of the body according as larger or smaller areas of skin surface drain into the glands of the regions in question. Extracting from Vierordt's tables the fact that the areas of skin surface which drain, respectively, into the glands of the neck, the axilla, and the groin, stand to each other, approximately, as the figures 1, 1·8, and 5, they compared these ratios with those representing the relative frequency of buboes in these areas, as taken from statistics of hospitals in Bombay, Karachi, and the Punjaub, and found a very striking resemblance, the latter being as the figures 1, 1 3, and 5·5.

A phlyctenule occasionally marks the point at which skin inoculation takes place, but, as this can only happen in those rare cases in which the virus is deposited between the upper and lower layers of the epidermis, it is by no means a common manifestation. It happened in the case of Dr. Sticker,* a member of the German Plague Commission, who became inoculated through an almost imperceptible scratch inflicted on the hand while performing a post-mortem examination; after the onset of slight

* 'Annual Report of the Municipal Commissioner, Bombay, 1896-97,' p. 127.

B. EXCITING CAUSES.

As the general circumstances which render probable the occurrence of some particular circumstance which directly causes the entrance into the body of the plague virus are described as predisposing causes, so the particular circumstance which directly causes the infection in any individual case (such as a plague post-mortem wound) might be said to be the exciting cause of such a case. As, however, it would be impossible to enumerate all the possible particular circumstances which might be exciting causes in different cases, it will be sufficient to consider, as the exciting cause of plague generally, the entrance into the body of the infective agent which gives rise to the chain of phenomena which determine a case to be one of plague.

The known attributes of this agent have been fully dealt with in the foregoing chapter, and its methods of entrance into the system have been shown to be by way of the skin, respiratory passages, or other mucous surface.

Of these channels, it has been inferred that infection is most commonly contracted by the skin. This inference is confirmed, as pointed out by the Indian Plague Commission,* by the fact that primary

* 'Report of Indian Plague Commission,' chap. iii., p. 70.

ave adduced doubt based upon the small proportion f plague pneumonia among disinfectors who inhale ie dust of infected places; doubts suggested by ie fact that the proportion of primary plague neumonic cases to total cases varies greatly in ifferent epidemics and different phases of the same pidemic; doubts suggested by the fact of plague neumonia predominating or being absent in particular epidemics, and doubts arising from absence f history of origination of primary plague pneumonia from contact with primary bubonic cases, and rom frequency of succesive cases of primary plague neumonia.

They have substituted a theory which takes into onsideration either that there may be something in he form or manner in which the infective material scapes from the body which favours conveyance of nfection into the lungs of persons attending on ases of plague pneumonia, or that there may be omething specific in the infective material which onditions the supervention of plague pneumonia when introduced into the lungs. They admit that here can be no question of any specific difference etween the bacilli which cause pneumonic and bubonic plague respectively, but suggest that there may be a difference in point of virulence; or that

general symptoms indicating that he had become infected, a small vesicle, accompanied by a burning and pricking sensation, appeared at the point of inoculation, in the contents of which plague bacilli were detected. In some instances a hair passes through such a phlyctenule; this would appear to indicate that the virus might gain entrance through an inflamed follicle.

Among mucous surfaces through which infection can be contracted, that lining the respiratory passages would appear to be the one most commonly selected, plague pneumonia accruing either by direct inhalation of the virus into the lungs, or by continuation of the inflammation from a point of inoculation in the nasal mucous membrane. According to Montenegro, when the latter occurs, a primary bubo of the deep cervical glands is always observed, but not so when the infection has taken place by inhalation of the virus, nor when plague pneumonia is artificially induced by intra-tracheal injection of plague cultivation.

As against the view that there is a simple interrelation between the introduction of plague bacilli into the lungs and the supervention of primary plague pneumonia,* the Indian Plague Commission

* 'Report of Indian Plague Commission,' chap. iii., p. 73

Most observers are agreed that infection through the mucous membrane of the alimentary canal is, if it happens at all, very rare. There is practically no evidence in support of its happening in Nature; but the possibility of its so occurring gains strength from the fact that some observers (*e.g.*, Bandi and Stagnitta*) claim to have infected animals through this channel, causing primary buboes in the mesenteric glands

* *Vide* Montenegro's work on Plague

the former may be associated with some other bacilli which favour their growth and contribute to the production of plague pneumonia; or, from the fact of the great difference in the character of the symptoms in different cases, that primary plague pneumonia may be a mixed infection in which the secondary rôle may be played at one time by one micro-organism, at another time by another.

The German Plague Commission* suggest, from a survey of the pathological changes in the lungs, that pneumococci may in many cases be agents in preparing the way for a subsequent development of the plague bacilli in the lungs

The *comparatively rare cases in which there are* submental, parotid, and deep cervical buboes are, in all probability, the result of inoculation through the pharyngeal, oral, or nasal mucous membranes.

There are one or two cases on record, notably that of Miss M., Nursing Sister in the Parel Hospital, Bombay, in which the virus undoubtedly gained *entrance through the conjunctiva, causing primary* post-aural buboes.

It would also appear that infection can occur through the genital tract, some few cases in which such happened having been reported.

* 'Report of the German Plague Commission,' p 74.

two or more often co-exist in the same individual, such types cannot be said to be pathologically distinct. Systems of classification, therefore, are not essential, but may be convenient for descriptive purposes, or for referring cases to definite types in statistics, a procedure which, during the course of an epidemic, might be of use for administrative purposes, it being recognised that some are more highly contagious and infectious than others, and that cases exhibiting primary pulmonary features are more prevalent during the middle than at any other period of an outbreak.

As such advantages are obtainable without any elaborate system of classification, there appears to be no necessity to multiply types merely on the grounds of the *severity* of symptoms, or the accidental difference in *primary characteristic* occasioned by the particular mode of entry of the infective agent into the body.

When, as occurs in the majority of cases, the virus primarily enters the lymph-stream from a point of inoculation either in the skin or some readily accessible mucous surface, the first pathognomonic sign is a visible bubo. This is not the case when it directly enters the blood-stream, or the mode of infection is by way of the respiratory

CHAPTER IV

SYMPTOMATOLOGY

General remarks and classification—General symptoms—Symptoms referable to particular systems: Lymphatic system; Nervous system; Circulatory system; Respiratory system, Digestive system; Cutaneous system; Genito-urinary system—Complications and sequelæ.

THE fact that plague manifests itself in such a variety of forms has led different observers to adopt various standards of classification into distinct types. The majority have selected as their basis the degree of prominence of primary symptoms referable to particular systems; while others have found it more convenient to describe certain main divisions based on the *severity* of symptoms, with subdivisions in each according to particular manifestations.

There being, however, no specific difference between the infective agent which produces any one so-called type or any other, and it being known that one type can be contracted from another, and that

lans) are naturally more confined to the first group, while the latter (the so-called *Pestis fulminans*, or *Pestis siderans*) are mostly of the second group.

Certain general symptoms are common to typical cases of both groups, though their course and severity are, necessarily, influenced by particular manifestations, and modified by the supervention of complications. It would therefore lead to useless repetition to describe separately the general symptoms of each group; but, while regarding a division into groups as useful for statistical purposes, all clinical requirements will be served by an enumeration, firstly, of the general symptoms of plague, and then of those referable to particular systems, any or all of which may be affected in individual cases, whether primarily of either group

Such particular symptoms as must of necessity be included among general symptoms, on account of the impossibility of effecting a clear line of demarcation, will also be included in connection with the systems to which they refer, and the reader will readily appreciate to what extent the general symptoms might be modified by the supervention of other particular manifestations should they appear.

passages or alimentary canal; though in the latter instances there may, for all we know to the contrary, be primary intra-thoracic or intra-abdominal buboes. A distinct natural division thus presents itself, taking advantage of which we have two varieties, viz., plague *with* primary external buboes, and plague *without* primary external buboes.

The former includes all cases with primary buboes in the visible glandular regions. Such are less fatal than those in the latter group, which includes, mainly, those cases in which the virus primarily enters the blood-stream (the so-called septicæmic); the air-passages (primary pneumonic); or the gastro-intestinal tract, if ever this does happen naturally, (abdominal).

It must not be lost sight of that primary cases in either group may become complicated by the supervention of manifestations peculiar to the other, a contingency which, so far as the first group is concerned, almost invariably happens in fatal cases. In either group there may also occur cases of such mildness as scarcely to be recognised (except by accident) as cases of plague, and also cases of such extreme virulence as to be fatal in the course of a few hours after the onset of symptoms; but the former (the so-called *Pestis minor* or *Pestis ambu-*

hot, and the face flushed. Severe frontal headache with vertigo and vomiting soon follow, and the vomiting, which appears to be of cerebral origin, does not allay nausea, and is followed by dryness of the fauces and mouth and intense thirst.

The expression of the face at this stage is either one of grave anxiety or of anger, and the speech is thick and hesitating, giving the impression of partial intoxication with confusion of memory. If the patient tries to walk, a want of co-ordination in his movements becomes evident, and when he sits or lies down, the attitude or decubitus is characteristic of extreme helplessness.

In most cases there is marked insomnia alternating with brief spaces of drowsiness, and, among these, delirium in the case of adults, and convulsions in the case of children, are often observed. In those cases in which insomnia is not a marked symptom, a tendency to coma-vigil is noticed at a very early stage.

The tongue becomes swollen and tooth-indented, and is protruded and withdrawn with difficulty, its surface is covered with a yellowish fur which is thickest posteriorly, the tip and edges being clean. The bowels may be relaxed or constipated, and there is generally no impairment of appetite

GENERAL SYMPTOMS OF PLAGUE.

Most observers are agreed that the incubation period of plague is comparatively short, ranging, in the majority of cases, from two to five days. The actual invasion has generally been described as sudden, and though there is, in most instances, an abrupt ushering in of acute symptoms, observation of a very large number of cases among passengers detained at inspection posts (as being probably infected, and in whom undoubted symptoms of plague subsequently appeared) would seem to establish the fact that the incubation stage is almost invariably characterized by one or more premonitory signs, such as malaise, mental and physical depression, slight pyrexia with a soft pulse, injection of the ocular conjunctivæ, a furred tongue with red tip and edges, slight diarrhœa, nausea, frontal headache with giddiness (which often causes an unsteady gait), or impairment of the mental processes (as indicated by hesitation or apparent disinclination to reply to questions)

After two or more days of such manifestations, a sudden rise of temperature, preceded by one or two more or less violent rigors, occurs. The pulse and respirations become accelerated, the skin dry and

upon the position in which the patient may be placed by the attendant, or upon the mental condition of the patient. The tongue becomes more dry, its fur brownish, and its edges bright red and shining. The respiration, even when the lungs are not involved, becomes rapid in a degree disproportionate to the acceleration of the pulse-rate; and there is often a slight cough.

The urine is scanty and high-coloured, or may contain blood, or be retained When diarrhœa is present the motions are generally bilious in character. The flushed countenance sometimes gives way to a more or less dusky hue, and this is an unfavourable sign.

In very severe and rapidly fatal cases the temperature often becomes subnormal on the day after it reaches the maximum, this crisis generally resulting in collapse, but a second or third rise, followed by crises, may occur before collapse and death supervene.

In less severe cases a slight remission occurs on the morning after the maximum pyrexia is reached, followed by an evening exacerbation; this is repeated for several days following, the course of the temperature then tending towards the normal by lysis, which in favourable cases lasts for seven or eight

The temperature quickly rises, reaching its maximum, in typical cases, with the supervention of particular manifestations, which may be on the second or third day, or later; and, simultaneously with the temperature rising, the other febrile symptoms become more marked.

The expression of anxiety or anger gives way to one of listlessness or apathy which is often mistaken for improvement, though really due to partial suspension of central nervous control over the facial muscles. *The speech becomes thicker and monosyllabic*, the weakness of the power of articulation sometimes going on into actual aphonia. The hearing is dulled and the patient is roused with difficulty, often showing apparent annoyance at being disturbed. The eyelids do not meet when attempts are made to close the eyes, and this leads to the ocular conjunctivæ becoming much injected and yellowish, and to a sunken appearance of the eyes; if these be inflamed the pupils are generally contracted, but otherwise they are normal or slightly dilated.

The pulse becomes more rapid, more compressible, *and dicrotic; the gait staggering;* and the decubitus dependent upon the presence of such circumstances as pain, dyspnœa, or jactitation attending delirium,

the powers, or by predisposing to the supervention of acute complications.

In those unfavourable cases in which death does not accrue by collapse following early crisis, the further course of the disease usually depends upon particular complications, the general symptoms being dependent upon these, and not necessarily diagnostic of plague The nature of the pulse, however, which is compressible throughout. and becomes running, thready, and imperceptible towards the end, is very significant, as are also the marked mental and physical depression, the painful and distressing insomnia, and the symptoms indicative of the suspension of central nervous control

Death may result by exhaustion following repeated hæmorrhages, or collapse after sudden hæmorrhage; by syncope following sudden exertion or violent delirium; by asthenia dependent upon hyperpyrexia or other particular cause; by asphyxia from mechanical pressure of buboes or infiltration around buboes, the retention of effete matters in the circulation, or extensive involvement of the pulmonary apparatus, etc., or by coma resulting from direct toxic action of the virus upon the nervous centres. It is not easy in most instances to ascribe death definitely to any one of these

days. The supervention of complications, however, necessarily modifies its course. Thus, the entry of the bacillus into the blood-stream gives it the characteristic irregularities observed in septicæmia; involvement of the lungs limits the diurnal variation and retards the lytical tendency; the appearance of a fresh bubo leads to a sudden unexpected rise; suppuration in a bubo causes a hectic tendency; sudden severe hæmorrhage brings on crisis, with collapse, etc.

With the *subsidence of the temperature* in favourable cases the more acute general symptoms gradually disappear; but convalescence is almost always protracted, and characterized by weeks of physical and mental prostration, during which sudden violent exertion is apt to result in cardiac failure and fatal syncope.

Many general symptoms, such as aphasia, loss of co-ordination of muscular movements, confusion of memory, etc., and particular manifestations, such as suppurating buboes, pulmonary *inflammation*, petechiæ, the so-called plague-boils, etc., may persist for prolonged periods after the establishment of convalescence; and these, with some of the sequelæ which will be described under that heading, sometimes lead to a fatal termination by exhaustion of

the powers, or by predisposing to the supervention of acute complications.

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influences; fatal cases being generally complicated, several of them probably act together, but it would appear that the *determining factor is in most cases* syncope, a suspension of the muscular power in the walls of the heart causing cessation of the circulation.

PARTICULAR SYMPTOMS OF PLAGUE.

Lymphatic System.—The earliest manifestation of this system being affected generally occurs from within a few hours to several days after the initial sharp rise of temperature, and usually takes the form of dull or lancinating pain in one or more of the glandular regions, with more or less marked tenderness, increasing in degree until slight swelling of the affected gland or glands becomes evident. Pain then often becomes so intense that the patient cries out at the mere apprehension of palpation; but as the swelling increases, and tension in the enlarging gland or glands is relieved by infiltration of blood or sero-sanguineous fluid into the surrounding tissues, it becomes less marked and often disappears altogether.

The swelling—or bubo, as it is called—varies in size from that of a medium-sized *shot to that of a*

large walnut, but may enlarge up to the size of a cricket-ball, according to the number of contiguous glands affected, and to the amount of effusion which occurs into the surrounding tissues.

There may be only one gland in a bubo, or several contiguous ones, or a whole chain. The effusion, which varies in extent and quality according to its position, is generally more profuse, and contains more blood, in cases with pectoral or axillary buboes than in those with cervical or femoro-inguinal ones; and in such cases has been known to involve the whole of one side of the chest, abdomen and back. When abundant, it is a source of danger not only from loss of blood, but because by pressure it is apt to cause œdema, etc., and, instead of resolving, it often leads to extensive sloughing, which lays bare the muscles and tissues as if the affected parts had been dissected. When it appears, the bubo, which at first is hard and well defined, becomes doughy and brawny to the touch, the skin, however, generally remaining freely movable over it.

There may be only one bubo, or several, and no gland in the body is free from liability to involvement. The relative frequency of buboes in the principal external glandular regions — viz, the femoro-inguinal, axillary, and cervical—stands, as

has been seen, approximately as the figures 5·5, 1·3, and 1 respectively; and, from a detailed analysis of no fewer than 16,132 bubonic cases, the regional, case mortality works out as follows, viz.:

	Cases.	Per cent
Cervical	1,006	70 5
Parotid	463	68 6
Right axillary	1,866	77·1
Left axillary	1,712	78·0
Right femoral	2,539	72 3
Left femoral	2,429	75 4
Right inguinal	1,988	70·1
Left inguinal	1,922	71·7
Multiple	2,207	70·0

From these figures, it would appear that cases with axillary buboes give a higher rate of mortality than those with buboes in any other region, and that cases with left axillary, left femoral, and left inguinal buboes are more fatal than those with right axillary, right femoral, and right inguinal buboes respectively.

Multiple bubonic cases are not necessarily more dangerous than single ones as long as the cases remain bubonic and the extension of the infection is by the lymphatics alone; but, when secondary infection of distant glands takes place by the infective agent entering the blood-stream, the cases,

being septicæmic, are consequently much more fatal than single uncomplicated bubonic cases. Buboes may break down and suppurate, undergo resolution, or persist as indurated masses for an indefinite time When they suppurate, the skin over them becomes inflamed or necrosed, and, on bursting or being opened, blood-stained pus with gland débris exudes, subsequent healing is slow, as indolent ulcers with undermined edges or sinuses often remain for weeks or months, and, when such eventually heal, extensive cicatrices are formed

Not only the glands, but the lymphatic vessels, often show signs of inflammation, or a whole set, or even a whole limb, may become involved in acute lymphangitis. This is most commonly observed in the lower extremities, and, when extensive, enhances the probability of a fatal termination.

Nervous System.—Evidences of this system being affected occur at a very early stage in the majority of cases. Even during the incubation period there are often premonitory manifestations, such as frontal headache, vertigo with slight unsteadiness in the gait, cerebral nausea, slow mental processes as indicated by disinclination to reply to questions, and restlessness which often takes the form of an irresistible desire to move from place to place.

These are generally all present together soon after the actual invasion occurs, and rapidly become worse, the slight unsteadiness in the gait passing into actual loss of co-ordination in muscular movements, the nausea leading to painful and uncontrollable vomiting, the slow mental processes amounting to actual lethargy, and the restlessness to delirium in adults and convulsions in children.

Added to these, there are generally pains in different parts of the body, such as in the back and along the course of nerves, weakness or loss of power of articulation (so constant as to be practically diagnostic of plague), loss of power of expression in the facial muscles, dulness of hearing and of the mental powers, disinclination to think (giving the impression of confusion or loss of memory), muscular tremors, distressing insomnia alternating with brief periods of drowsiness, impairment of the superficial reflexes, hyperæsthesia or anæsthesia, and local and general muscular spasms

The delirium may be of a low typhoid character, or wild and maniacal, as in delirium tremens. Delusions and hallucinations of all kinds are common, and there is frequently a homicidal tendency, or a desire to commit suicide by jumping from heights. Two instances of the latter occurred among cases

under the writer's own observation, both patients dying by throwing themselves from upper-story windows

The weakness in the power of speech, which is manifested by deliberate or monosyllabic utterance, such as occurs in glosso-pharyngeal paralysis, may be due to dryness of the mouth, swelling of the tongue, partial paralysis of, or want of co-ordination in, the muscles of speech, loss of memory of words, or disinclination to an effort of memory.

In severe cases, such symptoms as jactitation, carphology, subsultus tendinum, coma-vigil, or absolute coma, are superadded; and in protracted cases there are evidences of suspension of trophic influences, such as bed-sores and ulceration of the corneæ, which latter may, however, be due to inability to close the eyelids.

The involuntary passage of dejecta is comparatively rare, though sometimes present.

Circulatory System.—In typical cases, the temperature is fairly characteristic, generally reaching its maximum with the development of primary particular manifestations, exhibiting daily remissions and exacerbations for several days following, and declining by lysis which lasts for about a week.

The appearance of fresh particular manifestations

or the supervention of complications necessarily modifies its course. Sudden severe hæmorrhage causes *crisis; the entry of the microbe into the* blood leads to the irregularities observed in septicæmia; suppuration gives it a hectic character; and fresh buboes, the supervention of pulmonary symptoms, the development of abscesses, etc., cause sudden rises, as at the primary manifestation, and retard lysis.

The pulse is also characteristic; though bounding and apparently full in the early stages to a light touch, it is really readily compressible, and becomes rapidly weaker, then dicrotic, and, in severe cases, *running, thready, and imperceptible. It is invariably* very rapid, and the increased rate is out of the normal proportion to the respiration rate, which is also increased.

Though the temperature may be high, the extremities are generally cold, which condition, as well as the compressibility of the pulse and tendency to syncope, is probably due to weakness of the circulation in consequence of vaso-motor paralysis.

In the early stage of an attack there are often palpitation, throbbing in the head and neck, and pain in the cardiac region. The apex beat of the heart is distinctly visible, and its impulse is in-

creased, but it gradually becomes weaker and the diastole lengthened.

The blood does not readily coagulate, corpuscles show but little tendency to coalesce into rouleaux, and the leucocytes are increased in number.

There is a marked tendency to congestion of the internal organs, and to hæmorrhages, which may take the form of petechiæ in any position, extravasations, epistaxis, hæmoptysis, or bleeding from the genito-urinary or gastro-intestinal tracts. In most fatal cases, shortly before death, plague bacilli are abundant in the blood-stream

Respiratory System.—The time of appearance of signs of pulmonary involvement depends upon whether this is primary or secondary Certain symptoms referable to this system, such as dyspnœa, rapid respiration rate, slight cough, etc , are almost invariably present, even when there is no distinctive lesion, and are due to œdema following the congestion which occurs in the lungs in common with other organs.

When the lungs are primarily involved, the particular manifestations are abrupt, the general symptoms severe, and initial visible buboes absent. A tight, constricted feeling about the chest, associated with dyspnœa and rapid and shallow respiration, is

one of the earliest indications. Cough soon follows, with watery sputum, which is generally very abundant and sometimes highly blood-coloured. Occasionally viscid or frothy matter is expectorated, containing streaks of blood which does not coagulate; but the sputum never exhibits the rusty appearance observed in lobar pneumonia, and actual hæmoptysis seldom occurs.

Pain in the chest, though often present, is not a marked feature, but, if the cough be troublesome, there is much muscular pain and exhaustion, with disinclination to expectorate.

Insufficient aeration of the blood causes the skin to assume a bluish or dusky appearance, and, as the symptoms advance, the breathing becomes much laboured; thoracic expansion is limited, and during inspiration the upper part of the chest is raised and the lower part drawn in.

Percussion reveals the presence of isolated patches of consolidation, as in lobular pneumonia, and it would appear that this form is characteristic of plague—in all probability on account of hæmorrhagic obstruction in the smaller air-passages (1) setting up inflammation which either extends to the air-cells or leads to inflammation in them by irritation excited by the inhalation into them of in-

flammatory products from the obstructed tubules; or (2) resulting in collapse of the lung tissue behind the obstruction, which induces congestion and hyperæmia by retardation of the pulmonary circulation. Occasionally dulness is heard evenly over a whole lobe, but this is probably due to a number of patches of consolidation being contiguous, and not to the whole lobe being involved as in lobar pneumonia When the consolidated patches are deep and surrounded by healthy or emphysematous lung tissue, the percussion resonance is normal, or only slightly impaired, so that, in the early stages, evidences of consolidation are extremely difficult to find by percussion only

On auscultation, however, the moist and dry râles, which are audible all over, assume a metallic quality, or become crepitant, over the affected parts, and the presence of crepitation affords conclusive evidence of actual pulmonary involvement; the sputum is generally loaded with plague bacilli, and yields excellent cultures on artificial media.

Gangrenous inflammation in the lungs, which appears to have been so common in the outbreaks of the fourteenth century, has only been very rarely observed in recent outbreaks.

Cases in which this system is primarily involved

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death-rate from plague in Bombay, there remained a large and unsatisfactorily explained increase, which had been assigned to remittent fever and diseases of the respiratory organs. Further investigations showed that many of these cases were actually cases of plague, in which the disease manifested itself chiefly by lobular inflammation of one or both lungs, and in which the true nature of the affection was demonstrated by the discovery of plague bacilli in the sputum.'

Digestive System.—The condition of the tongue is fairly characteristic. In the early stage it is coated with yellowish fur, which is thickest posteriorly, the tip and edges being clean, later on it becomes swollen, tremulous, tooth-indented, and dry; is protruded and withdrawn with difficulty; the fur becomes darker and glistening, or peels off, leaving patches of raw-looking surface, and the tip and edges have a bright red and shining appearance.

The mouth and fauces are dry, the gums and teeth covered with sordes, and, though the appetite is not often impaired, swallowing is effected with difficulty, especially in cases with parotid or deep cervical buboes. Thirst is generally extreme, and hiccough, if present, a most distressing symptom.

are, as a rule, rapidly fatal, death occurring by exhaustion and asphyxiation. In those which recover or linger for a time, it is common to find the lymphatic system involved by secondary infection.

When this form of pneumonia occurs as a complication in cases exhibiting other primary characteristics, it runs much the same course, and may appear at any time, though seldom before the fifth or sixth day. In rare cases, both the respiratory and lymphatic systems are simultaneously affected from the beginning; such a condition is most probably the result of a double infection.

Acute laryngitis may occur in the course of a case with primary deep cervical buboes, and is a serious complication owing to its liability to cause death by œdema of the glottis.

In Appendix ii. of the 'Report of the Indian Plague Commission,' Professor Fraser writes that 'the pneumonic form of plague is of great interest in reference to the extension of plague and the efficacy of the measures for its control. Although well known in many previous epidemics of plague, it appears to have been first recognised in the present Indian epidemic by Captain Childe, I.M.S., who found that, coincidentally with the increased

death-rate from plague in Bombay, there remained a large and unsatisfactorily explained increase, which had been assigned to remittent fever and diseases of the respiratory organs. Further investigations showed that many of these cases were actually cases of plague, in which the disease manifested itself chiefly by lobular inflammation of one or both lungs, and in which the true nature of the affection was demonstrated by the discovery of plague bacilli in the sputum'

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Nausea is an early symptom, and is soon associated with vomiting, which does not allay it; the vomited matter is at first bilious, then mixed with food, and often of the coffee-ground variety towards the end; it sometimes, though rarely, contains pure blood which does not coagulate.

During the recent outbreaks constipation has been a more prominent feature than diarrhœa. When the latter is present, the stools, of which there are generally six or more in the twenty-four hours, are bilious in character, offensive in odour, and occasionally contain blood, though rarely in large quantities, and there is always epigastric and lumbar pain and tympanites.

Enlargement of the liver and spleen is almost invariably present, and deep palpation over these organs elicits marked tenderness.

Hojel has described some cases closely resembling enteric fever, in which, after death, plague lesions were found in the solitary and agminated glands of the small intestine. Such are to be distinguished from enteric by the eruption being petechial; also by the early abdominal distension, and its association with epigastric and lumbar pain, and with retching and vomiting; and by the nature of the general symptoms and the character of the stools. In

doubtful cases confirmatory evidence can be obtained by recourse to bacteriological tests.

The tonsils and pharynx are often inflamed and ulcerated, and acute pharyngitis is apt to cause fatal œdema.

Cutaneous System.—In the early stages of an attack the skin is flushed, hot, and extremely dry, *remaining so until well after the establishment of* lysis In cases in which crisis occurs, it becomes clammy and damp when the temperature sinks below normal.

Though there are certain characteristic cutaneous lesions, it cannot be said that there is any definite eruption. Petechiæ may be found in any position, but are most frequent in the affected limb or limbs, and most numerous over the buboes themselves. Extravasations of blood often occur, and when present are generally in the vicinity of buboes Pustules, many of which have a dark colour from admixture of their contents with blood from capillary hæmorrhage, are common about the trunk and limbs, and are known as 'plague boils' or 'black boils'; they seldom exceed an inch in diameter, and generally commence as vesicles, and, after bursting, either heal by scabbing or leave indolent or sloughing ulcers

As happened in the case of Dr. Sticker (p. 59), and has been observed in other cases in which the infective agent has evidently been primarily deposited between the upper and lower layers of the epidermis, a phlyctenule sometimes marks the point of inoculation. Commencing as a small papule, in and around which a stinging or pricking sensation is felt, it soon becomes vesicular, surrounded by an areola, and full of clear fluid containing plague bacilli; this fluid gets turbid in the course of two or three days, and the vesicle enlarges and becomes umbilicated. In about a week it bursts, discharges a slough, and either heals by scabbing or leaves an indolent ulcer.

Another cutaneous manifestation consists in areas of skin connected with lymphatics near buboes becoming inflamed and necrosed, and, after sloughing off, leaving either indolent ulcers with undermined edges, or spreading ulcers which lead to deep sloughing and severe hæmorrhage. These areas vary in diameter from 2 or 3 to 9 inches or more, and are apt to be mistaken for bed-sores if situated in positions in which such usually occur; but they may occur anywhere, and are more generally found in positions in which there has been no pressure.

Occasionally, though rarely, gangrene attacks the skin of the extremities and spreads quickly, involving the whole or part of a limb.

In advanced stages the skin, which is at first flushed, assumes a dusky or bluish hue on account of insufficient aeration of blood in consequence of pulmonary œdema or consolidation.

Genito-Urinary System.—Pain is often present over the kidneys, and the urine is generally scanty and high-coloured, though micturition occurs frequently. In a large number of cases there is retention of urine, and, in some, complete suppression. The specific gravity of the urine is mostly high, and its reaction acid. Albumen is nearly always present, and is associated with the presence of hyaline and epithelial tube casts. The normal quantities of urea, uric acid and chlorides are diminished.

Occasionally hæmaturia occurs, and it is not uncommon to find blood corpuscles in the urine; but, there being no known method of isolating plague bacilli when in company with many contaminating micro-organisms, it is extremely difficult to find these in urine or fæces, though some observers have claimed to positive results in this direction.

Plague induces menorrhagia or metrorrhagia in

females, and has been known to bring about menstruation in amenorrhœic subjects. It is an extremely serious complication of pregnancy, especially after the fourth month, almost invariably leading to miscarriage and death of both mother and child. In rare instances one or both may live, miscarriage be averted, or the child escape infection. In one case, almost at full term, a plague-infected mother was delivered of a child apparently quite well, the mother dying of post-partum hæmorrhage. Ten hours after birth buboes appeared in the child's groin[illegible] axillæ, and it died eighteen hours after. After [illegible]h plague bacilli were found in the spleen and blood, and in the retroperitoneal, femoral, and axillary glands.

Infected nursing mothers do not necessarily impart the plague *to their offspring by suckling them.* Of sixty-one cases recorded by Leumann, thirty-seven infants (under eighteen months old) escaped infection, though fourteen of them (mostly under a month old) died of other diseases; the remainder died of plague.

COMPLICATIONS AND SEQUELÆ.

Cases belonging to either of the two principal groups commonly become complicated by the super-

vention of manifestations peculiar to the other. This almost invariably happens among fatal cases of the group with primary external buboes. As such, however, is merely the extension of the same infective process to other parts of the same organism, it can scarcely be strictly regarded as a complication. The very distinctive particular manifestations, however, make it common to speak, for example, of a bubonic case being complicated by secondary pneumonia, etc It is, nevertheless, quite possible that a bubonic case may contract pneumonia by fresh infection, and not by the extension in the system of the process causing secondary infection, and *vice versâ*.

The most common foreign complications observed during the recent outbreaks have been relapsing fever (during famine times), cholera (whenever that disease was epidemic), malarial fevers, dysentery, arthritis, and pulmonary complaints

It is, of course, possible that one of many other diseases may supervene during a plague attack; but none are peculiar to plague, excepting those which, though not invariable concomitants, are, when present, to some extent, if not wholly, dependent upon the infective process or toxic action of the virus, and they should more properly be regarded as sequelæ. Among the principal of them are affec-

tions of the nervous system, including peripheral neuritis; mental impairment; catalepsy; muscular spasms; paralyses, such as partial or complete hemiplegia, paraplegia, facial paralysis, and other local forms; affections of the eye, such as acute inflammation of the cornea with ulceration and perforation, or even disorganization of the globe; abscesses and boils; anæmia; dysentery; thrombosis; erysipelas, and extensive sloughing causing hæmorrhage by involving large vessels. As has been seen, these sequelæ sometimes lead to a fatal termination by exhaustion of the powers, or by predisposing to the supervention of acute complications.

CHAPTER V

PATHOLOGY AND MORBID ANATOMY

General remarks—Cutaneous system—Lymphatic system—Respiratory system—Circulatory system—Nervous system—Alimentary system—Genito-urinary system—Other organs

In his summary of the pathological conditions produced by the plague virus (Appendix ii., para 30, of the 'Report of the Indian Plague Commission'), Professor Fraser draws attention to the fact that the different manifestations are largely explicable by distinctive vascular changes which are not observed in any other infective disease, and which consist of universal dilatation and engorgement of veins and smaller bloodvessels, with hæmorrhages, both minute and of large amount, in nearly every part of the body.

He adds that 'it is of some interest to note that

the vascular changes, and especially the pervading and characteristic tendency to extravasation of blood in almost every part of the body, are closely reproduced in the toxæmia caused by the organic poison secreted by the venom glands of several species of serpents, such as the black snake (*Pseudechis porphyriacus*) of Australia.'

In the absence of particular signs, such as external buboes, phlyctenules, sloughs, well-marked petechiæ or subcutaneous extravasations of blood (as distinct from ordinary post-mortem lividity), there is nothing to justify, by a mere superficial inspection of a body, a definite conclusion as to death having been caused by plague, especially if the skin be dark. Owing, however, to the characteristic tendency to hæmorrhages, careful and minute surface inspection seldom fails to reveal the presence of scattered petechiæ, and their presence is sufficient to warrant a reasonable suspicion that death was so caused.

As after other diseases characterized by physical prostration, post-mortem rigidity is of comparatively short duration, and not very much pronounced in degree. On incising the skin, the blood is observed to be fluid, subsequent coagulation tardy, and the serum, if collected, to exert an inhibitory influence on the growth of plague bacilli in artificial media.

In the following description, the characteristic lesions referable to particular systems will be found separately grouped, only such signs as are peculiar to plague being included, it being remembered that in many cases evidences of other diseases may coexist.

CUTANEOUS SYSTEM.

Discoloration, distinct from post-mortem lividity, and occasioned by small or large subcutaneous extravasations of blood, is almost invariably present in different situations. Sometimes the only evidence of extravasation is the presence of petechiæ, and these are generally most numerous in the vicinity of buboes. Papules, vesicles, or pustules may exist, also scabs or unhealthy ulcers The contents of the pustules are often black in consequence of admixture with blood from capillary hæmorrhage. In the clear contents of vesicles plague bacilli are sometimes found, especially in that of those situated near buboes, and it is probable that they mark the point of entry of the virus into the system.

The skin over buboes may present a necrotic appearance, due either to its breaking down prior to the bursting of the buboes, or to the action of escharotics applied in the early stages.

Necrosed patches of skin or large sloughing ulcers may also be present, and they are distinguishable from bed-sores by being found in situations where there has been no pressure.

Diffuse swelling around buboes occasioned by infiltration into the surrounding tissues is often observed, and, associated with it, œdema on the distal side of buboes, from pressure upon adjacent vessels.

LYMPHATIC SYSTEM.

The lymphatic vessels, excepting those associated with buboes, are seldom found to be involved. Occasionally, in cases with lymphangitis, injection of the walls and other evidences of acute inflammation may be observed in whole sets of lymphatics, or in those of an entire limb.

The glands, however, are almost invariably found to be involved in one or more situations, and no gland in the body is free from liability to involvement. They may only be enlarged, congested or engorged with blood, or may form the nuclei of buboes, and there may be only one, or several, or a whole chain in any individual bubo.

Their appearance on cutting into a bubo differs according to the age of the bubo. In early fatal

PLATE VI



SECTION SHOWING INFILTRATION FROM BUBO INTO ADIPOSE TISSUE.

cases the actual gland tissue shows but little change except in colour, and this depends upon the degree of engorgement with blood; if this be excessive, there is a certain amount of tumidity, but the gland substance is not easily broken down, and the gland is easily distinguishable from the masses of coagula and the engorged areolar tissue which, together with it, form the bubo In older cases the substance is easily broken down, though, perhaps, only in parts; and the gland or glands may be so intimately mixed with coagula, engorged and œdematous tissue, large vessels, etc., as to form a homogeneous mass, and to be indistinguishable

The infiltration from the affected glands does not only pervade the immediately surrounding areolar tissue, but may be found to have forced its way into the substance of the muscles, or, as in pectoral and axillary buboes, to have travelled for considerable distances, extending, for example, down the arm, or invading the whole of one side of the chest, abdomen, and back.

Childe* has demonstrated that the association of large vessels with buboes is often the cause of the entry of the microbe into the circulation, by the

* *Vide* 'Report of Indian Plague Commission,' Appendix ii, p. 433.

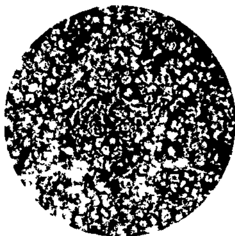
extravasated blood in the walls of the veins becoming continuous with the blood in their interior.

In the majority of cases, glands in different parts of the body, both superficial and deep, though not forming buboes, are observed to be congested, swollen, and engorged with blood. It is also not uncommon to find internal glands, such as the iliac, mesenteric, retroperitoneal, and others, very much enlarged and hæmorrhagic in cases in which the superficial glands are but little, if at all, involved.

Plague bacilli are abundant in the pulp of affected glands, *but generally disappear when the glands* break down or suppurate. It is true that they are often found in pus from buboes, but this association would appear to exist only in cases in which glandular pulp remains still unbroken down in suppurating buboes. They are also found *with blood cells* in the infiltration surrounding the glands, and are commonly seen in the lymphatic vessels associated with buboes

In the rapidly fatal cases described as septicæmic, in which the bacillus primarily enters the blood-stream, or in multiple bubonic cases in which distant buboes appear as the result of secondary infection through the medium of the circulation, the appearances are somewhat different. The tissues surround-

PLATE VII



SECTION OF GLAND FROM SIMPLE BUBONIC CASE, SHOWING BLOODVESSEL FREE FROM PLAGUE BACILLI, BUT FILLED WITH LEUCOCYTES. PLAGUE BACILLI TOGETHER WITH MIGRATED LEUCOCYTES APPEAR IN THE SURROUNDING GLAND TISSUE.

ing the glands are seldom or never engorged, and the affected glands retain their anatomical characters. The bloodvessels are distended, and hæmorrhages occur in parts into the gland tissue; the lymph channels also are distended with lymph cells, and, as demonstrated by Childe,* the distension of the blood and lymph vessels is always most marked at the hilum, at which spot also there may be occasional hæmorrhage into the areolar tissue. In the parts of the gland into which hæmorrhage occurs, softening and breaking down often follow in varying degrees, and gland débris, with broken-down cells and plague bacilli, are found.

RESPIRATORY SYSTEM.

The larynx and trachea are invariably injected, and, occasionally, there are hæmorrhages into the swollen mucous membrane. Sometimes œdema of the glottis is observed, especially in those cases showing evidences of acute laryngitis or pharyngitis, or in which there are deep cervical buboes

Frothy sanguineous fluid is often found in the bronchial tubes, the mucous membrane of which is always congested, and the lungs, generally, are en-

* Report of Major Lyons, I.M.S., President Bombay Plague Research Committee.

gorged with blood. Frequently, hæmorrhages are found in the lung substance or on the surface, also scattered over the pleura or in the mediastina.

Sero-sanguineous fluid is sometimes found in the pleural cavity, and in rare cases inflammatory adhesions also.

When the lungs are primarily involved, or secondary pneumonia has supervened, the above conditions are more marked; the walls of some of the alveoli are broken down by the severity of the hæmorrhage, and patches of catarrhal inflammation, varying in size, are scattered throughout the lungs. These patches, which are surrounded by belts of engorged lung tissue, may be distinct and separated from each other by clear, œdematous, or emphysematous lung substance, or may be contiguous or coalesced into larger patches. Sometimes a whole lobe is found to be thus consolidated, and when this happens the physical signs closely resemble those of croupous pneumonia. This has given rise to the impression that lobar as well as lobular pneumonia may occur as a manifestation of plague; but the greater weight of evidence is in favour of the latter being characteristic of the disease, physical indications resembling those of the former variety being always due to the coalescence of contiguous patches

of catarrhal inflammation into large areas of consolidated lung. The patches may be deep or superficial, and when superficial are seen to bulge out from the surface of the lung, and often to form centres from which evidences exist of extension of the inflammatory process into the pleura.

The air-cells in the affected areas are filled with an accumulation of epithelial elements, granular débris, and cells resembling leucocytes, intimately mixed into a gelatinous mass in which plague bacilli, often in association with Fraenkel's diplococci, or streptococci, abound. It is not common, however, to find the contents puriform as in the later stages of ordinary catarrhal pneumonia.

The patches are at first red, and later on become grey, they are quite solid, and do not float on water.

There is generally congestion and swelling of the bronchial glands, and sometimes hæmorrhage into their substance The axillary and cervical glands may also show slight enlargement or congestion, but in early fatal cases lymphatic involvement is rare.

CIRCULATORY SYSTEM

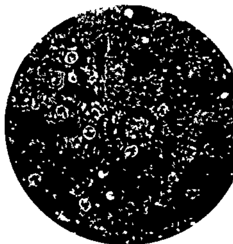
The blood remains fluid, and shows but little tendency to coagulate. The serum, if collected,

exerts an inhibitory effect upon the growth of plague bacilli in artificial media. There is a tendency to universal dilatation of the veins and smaller bloodvessels, and to large and small hæmorrhages, all over the body. These hæmorrhages occur even into the walls of the vessels, being more numerous in those of veins than of arteries, and, as has been seen, extravasated blood in the walls of veins associated with buboes is often the means of permitting the microbe to enter the circulation by becoming continuous with the blood in their interior. In arteries the inner coat remains intact, the extravasation not extending beyond the outer and middle coats.

It is common to find sero-sanguineous effusion, varying in quantity from a few drachms to a few ounces, in the pericardial cavity, and numerous petechial hæmorrhages are almost invariably present on both layers of the pericardium.

The muscular walls of the heart are sometimes unaffected, but more frequently are soft, flabby, and friable, owing to rapid degeneration of the muscular fibres, and œdematous on account of engorgement and hæmorrhage. This degenerated condition of the muscle is associated with dilatation, and is the cause of the frequent occurrence of fatal syncope.

PLATE VIII



SECTION OF LIVER FROM CASE OF PLAGUE SEPTICÆMIA

A clump of plague bacilli in capillary is seen in the centre

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In all cases the right side of the heart is dilated and contains post-mortem coagula

Hæmorrhages are sometimes seen on the endocardium, but the valves are not usually affected, though the openings which they guard are nearly always widened as an effect of the general dilatation

In fatal cases plague bacilli are generally numerous in the blood-stream shortly before death, except in primary pneumonic cases; in these death often occurs by asphyxiation before the microbe enters the circulation.

NERVOUS SYSTEM

The cerebral membranes and sinuses are generally congested, and petechial hæmorrhages are common in the former

Occasional punctate hæmorrhages are found in the cerebral tissue, associated with œdema; but the tissue itself is never pathologically involved.

Except for intense congestion, the spinal cord is normal, as are also the nerve trunks and branches.

It would therefore appear that the nervous symptoms are due mainly to the toxic action of the virus upon the nerve centres. This is further

evidenced by the fact that such manifestations generally gradually disappear, without leaving any traces of their existence in cases which recover.

As has been seen, the centres which control volition and special sense are not the only ones affected, but the toxic action also commonly causes suspension of trophic influence.

ALIMENTARY SYSTEM.

The salivary glands are generally congested, as is also the mucous membrane of the pharynx; and acute pharyngitis is sometimes present. The tonsils are swollen and often inflamed, and the walls of the œsophagus congested and speckled with petechial hæmorrhages.

Congestion of the mucous membrane and œdema of the walls usually pervade the entire gastro-intestinal tract. Petechiæ are also scattered throughout this region, though they are more numerous in the stomach and large intestine than in the small intestine.

Besides petechiæ, there are often extensive hæmorrhages into the submucous tissues of the stomach, or into its cavity, especially at its cardiac end.

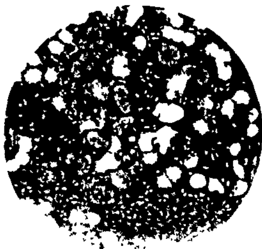
The solitary and agminated glands of the small intestine are swollen and congested, but never ulcerated. The retroperitoneal and mesenteric glands, also, are generally swollen and congested, and often have hæmorrhages into their substance.

The condition of the spleen is very characteristic. It is invariably much enlarged, engorged with extravasated blood, and undergoing rapid degeneration. The capsule is studded with petechiæ, and the consistence of the substance is soft and pulpy. The engorged state of the Malpighian bodies gives to a section surface a granular appearance and deep-red colour. Blood and spleen cells are intimately mixed around the bunches of engorged capillaries, and subcapsular hæmorrhages make the surface lumpy and uneven. Plague bacilli are commonly found in the hæmorrhagic areas and in large numbers among the spleen cells.

The liver is also enlarged and engorged, and sometimes presents the appearance recognised as nutmeg liver; the substance, however, is more often soft and pulpy from degeneration, the cells being cloudy and indistinct, and the nuclei badly stained; occasionally yellow necrotic patches are found scattered throughout the organ.

Petechiæ are common on the surface, and exten-

PLATE IX.



SCRAPING FROM SPLEEN, SHOWING PLAGUE BACILLI WITH SPLEEN CELLS AND LEUCOCYTES

lining is studded with petechiæ, as is also that of the bladder.

The suprarenal capsules are sometimes engorged and œdematous, but otherwise normal.

Plague bacilli are commonly seen in the renal tissues, especially among the blood cells in the tubules into which hæmorrhage occurs.

The genital organs are generally unaffected; but, in cases in which abortion has occurred, the sub-involuted uterus is engorged and œdematous, as are also the ovaries, and hæmorrhagic infiltration may be found between the layers of the broad ligament.

OTHER ORGANS.

Hæmorrhages are often found in the mesentery, the retroperitoneal connective tissue, beneath the conjunctivæ, under the scalp, on the under surface of the diaphragm, and elsewhere

The thyroid and mammary glands are occasionally seen to be engorged with blood, but are otherwise normal.

Bone-marrow is congested, and hæmorrhage is sometimes found beneath the periosteum of bones. Cartilage appears to be unaffected, but infective inflammation of the fringe-like processes of the synovial membrane of the knee-joint has been recorded.

sive hæmorrhages in the substance. Minute hæmorrhages occur in the mucous lining of the bile-ducts and gall-bladder, the latter being generally distended and full of watery bile.

As in the spleen, plague bacilli are found in large numbers in the liver, especially in the hæmorrhagic areas.

The pancreas is generally unaffected, but sometimes is engorged with blood.

GENITO-URINARY SYSTEM.

The kidneys are generally intensely congested, and are sometimes found to be imbedded in extravasated blood. The capsule is easily separable, and petechiæ are common on the surface.

Minute hæmorrhages also occur in the mucous lining of the pelves and calices, and sometimes coagula, the result of more extensive hæmorrhages, are found in the pelves.

The glomeruli are engorged, and the epithelium of the tubules generally in a state of parenchymatous *degeneration*. All the bloodvessels are distended, and sometimes extensive hæmorrhages are found in the renal tissue.

The ureters are congested, and their mucous

history of a somewhat abrupt appearance, leaves no room for doubt, especially if plague be prevalent.

Such general symptoms include, mainly, a high temperature, a furred tongue with red tip and edges, suffused conjunctivæ, a soft pulse, a listless appearance, hesitating or monosyllabic utterance and other evidences of impairment of the mental processes

During the course of an epidemic, however, the presumption is that the presence of tender and swollen glands which cannot be accounted for on specific, constitutional, or traumatic grounds is due to a mild invasion of plague, and it is of importance that this should be recognised, not because of any danger to those affected, but from the probability of their becoming centres of infection to others

By no means, however, is the recognition so easy of the large group of cases in which external buboes are not an early manifestation, or are absent altogether. This group includes all cases exhibiting primary pulmonary phenomena, primary characteristics referable to the gastro-intestinal apparatus, or indications of the direct primary entrance of the microbe into the blood-stream (the so-called septicæmic).

Beyond a strong suspicion that such are cases of

CHAPTER VI

DIAGNOSIS AND PROGNOSIS

A. Diagnosis: (*a*) Clinical diagnosis; (*b*) Differential diagnosis—(1) *Cases with primary external buboes*—(2) *Cases* without primary external buboes—(i.) Cases exhibiting primary pulmonary phenomena—(ii.) Cases in which the primary phenomena are referable to the gastro-intestinal apparatus—(iii.) Cases in which the microbe has presumably primarily entered the blood-stream; (*c*) Bacteriological diagnosis—(1) Microscopical examination of blood and of the products of the disease—(2) Diagnosis by cultivation methods—(3) Diagnosis by inoculation experiments—(4) Serum diagnosis—B. Prognosis.

A. DIAGNOSIS

(*a*) CLINICAL DIAGNOSIS.

THE recognition of typical cases exhibiting primary external buboes is never a matter of difficulty, excepting those mild cases (*Pestis minor* or *Pestis ambulans*) in which diagnosis is rendered difficult by the absence of those symptoms, the combination of some or all of which with painful buboes, and a

(2) *Cases without Primary External Buboes.*

(i.) *Cases exhibiting Primary Pulmonary Phenomena.*—The physical signs of such cases most frequently resemble those of lobular pneumonia, but the suddenness of the onset of the symptoms and their rapid development, the watery nature of the sputa, the fact that blood when present in the sputa does not coagulate, the extreme prostration and the presence of other general signs of plague, all combine to render it extremely improbable that one so affected is merely suffering from pneumonia. In those cases, moreover, which are not rapidly fatal, the secondary involvement of the lymphatic system (characterized by the appearance of secondary external buboes) is sufficient evidence to warrant a positive diagnosis of plague. The physical signs, however, sometimes resemble those of lobar pneumonia on account, as has been seen, of the coalescence of contiguous patches of affected lung into large areas of consolidation; but the rusty appearance of the sputa so characteristic of this form is never seen in plague pneumonia.

(ii.) *Cases in which the Primary Phenomena are referable to the Gastro-Intestinal Apparatus.*—Such cases have to be distinguished from cases of

plague, arising from the association of the particular phenomena with some of the general symptoms of plague, the consideration that plague is prevalent at the time, and the possibility of those affected having been particularly exposed to infection, a fairly presumptive conclusion can only be arrived at by a careful process of elimination or differential diagnosis, and a confirmatory one only by bacteriological tests.

(b) DIFFERENTIAL DIAGNOSIS.

(1) *Cases with Primary External Buboes.*

Before the appearance of a bubo in any particular case, the initial rigor and rise of temperature are apt to be mistaken for ague; and when this is disproved by the absence of a cold or sweating stage, and by the temperature remaining high, for remittent fever. The appearance of one or more buboes, however, and the rapid development of the general symptoms of plague, soon negative the latter suspicion and establish the diagnosis of plague.

If it be suspected, in the absence of marked general symptoms, that the buboes may be of venereal origin, such a suspicion would be disproved by the absence of local points of inoculation and of history of probable infection.

(2) *Cases without Primary External Buboes*

(i.) *Cases exhibiting Primary Pulmonary Phenomena.*—The physical signs of such cases most frequently resemble those of lobular pneumonia; but the suddenness of the onset of the symptoms and their rapid development, the watery nature of the sputa, the fact that blood when present in the sputa does not coagulate, the extreme prostration and the presence of other general signs of plague, all combine to render it extremely improbable that one so affected is merely suffering from pneumonia In those cases, moreover, which are not rapidly fatal, the secondary involvement of the lymphatic system (characterized by the appearance of secondary external buboes) is sufficient evidence to warrant a positive diagnosis of plague The physical signs, however, sometimes resemble those of lobar pneumonia on account, as has been seen, of the coalescence of contiguous patches of affected lung into large areas of consolidation; but the rusty appearance of the sputa so characteristic of this form is never seen in plague pneumonia

(ii.) *Cases in which the Primary Phenomena are referable to the Gastro-Intestinal Apparatus.*—Such cases have to be distinguished from cases of

enteric fever, and they differ therefrom by the eruption being petechial; by the abdominal distension occurring early, and being associated with epigastric and lumbar pain, and with retching and vomiting; by the character of the stools (which are bilious, offensive, and occasionally mixed with liquid blood); and by the nature of the general symptoms.

(iii.) *Cases in which the Microbe has presumably primarily entered the Blood-stream.*—These can be distinguished from cases of such affections as uræmic coma, which they often resemble, by the absence of history of kidney disease; acute alcoholism by the absence of smell indicating such, or by the history; epilepsy by the absence of the special signs of that disease, or by the history, etc. But there are conditions—such as some manifestations of cerebral apoplexy—which these cases closely simulate, and from which they cannot be distinguished, even by bacteriological tests, during life. In cases, however, of this nature, which are not rapidly fatal, the supervention of secondary buboes or pulmonary symptoms aids in establishing a diagnosis.

(c) BACTERIOLOGICAL DIAGNOSIS.

(1) *Microscopical Examination of Blood and of the Products of the Disease.*—It is extremely rare to

find plague bacilli in the blood in large numbers, except immediately before death in fatal cases. Their absence therefrom in early stages of an attack, and in cases which recover, must not, therefore, be regarded as negativing a diagnosis of plague.

They are generally present in large numbers in the sputa of plague pneumonic cases at all stages of an attack, and in the contents of buboes and plague blisters or boils until the supervention of suppuration, when, as has been seen, they probably get largely supplanted by the streptococci of pus, and partly or wholly disappear. While their presence, therefore, in the latter products may be regarded as conclusive evidence of plague, their absence does not necessarily justify negative conclusions.

(2) *Diagnosis by Cultivation Methods.*—These have a decided advantage over simple microscopical examination, in that the organisms, by becoming multiplied, are more easily detected. This advantage is of special value in the case of blood. It must be remembered, however, that the presence of contaminating micro-organisms may exert an inhibitory effect on the growth of the organisms; but, as pointed out by the Indian Plague Commission,* while a positive result obtained by the employment

* 'Report of Indian Plague Commission,' chap. iii., p. 63.

of cultivation methods will be more conclusive than a positive result obtained by simple microscopical examination, a negative result (where contaminating micro-organisms appear in the culture) will, considered as evidence of the absence of plague bacilli, be less conclusive than a negative result obtained by simple microscopical examination.

The exaggerated involution forms demonstrated by Hankin* as being produced by cultivation on agar-agar containing from 2½ to 3½ per cent. of common salt would seem to be diagnostic of plague, the *phenomenon not* being *common to pathogenic* micro-organisms. Similarly, the stalactite form of growth demonstrated by Haffkine† as occurring by cultivation in bouillon to which oil or ghee has been added, and the falling of these stalactite-like colonies on gentle agitation, is absolutely peculiar to plague. It has also been seen that Klein‡ considers that the filamentous forms of the plague bacillus produced by cultivation in gelatine are of diagnostic value.

(3) *Diagnosis by Inoculation Experiments.*—Inoculation of an animal for confirming a diagnosis of plague may be considered to justify a positive con-

* *Vide* Chapter II., p. 24. † *Vide* Chapter II., p. 27.
‡ *Vide* Chapter II., p. 24.

clusion, if, on the death of the inoculated animal, plague bacilli are found in its blood or spleen; but the method is not a reliable one as a test for isolating the plague bacillus when in company with contaminating microbes.

(4) *Serum Diagnosis.*—The fact that agglutinating substances are found in the blood of animals and men who have suffered from plague led the German Plague Commission to conduct a series of investigations to ascertain whether the phenomenon could be put to practical use as a means of diagnosis in doubtful cases They concluded,* however, that the practical utility of the method is limited, for the double reason that definitely negative results are often obtained in the cases of persons convalescing from plague, and that the bacteria in a culture are, even in the absence of a specifically active serum, so massed together into clumps as to render it difficult to decide by microscopical examination whether agglutination has or has not been obtained by the serum.

Regarding this method the Indian Plague Commission express themselves as follows 'We think that the difficulties and fallacies of the serum diagnosis of plague is rendered uncertain, not only

* 'Report of German Plague Commission,' p. 321.

of cultivation methods will be more conclusive than a positive result obtained by simple microscopical examination, a negative result (where contaminating micro-organisms appear in the culture) will, considered as evidence of the absence of plague bacilli, be less conclusive than a negative result obtained by simple microscopical examination.

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B. PROGNOSIS.

In the case of a disease the mortality from which ranges, under varying circumstances, from 65 to 90 per cent., the prognosis cannot be otherwise than invariably grave. It is, moreover, impossible to lay down any general rule for graduating the standard of gravity, seeing that it has so frequently happened, in the experience of all who have been closely associated with the disease in its clinical aspects, that cases appearing to be on a fair way to recovery have suddenly taken a turn for the worse and died, while others whose conditions have afforded no grounds for hope of improvement have recovered.

It may, generally, be said that cases without primary external buboes are more fatal than those with primary external buboes provided the latter be uncomplicated; and that, of the former, the highest mortality has been recorded among cases exhibiting primary pulmonary phenomena

Among bubonic cases, from an analysis of over 16,000 cases (*vide* Chapter V., p. 76), it would appear that cases with axillary buboes give a higher death-rate than those with buboes in any other region, and that cases with left axillary, left femoral, and left inguinal buboes are more fatal than those with

by the fact that plague bacilli are normally agglomerated together into masses by the intermediary of their glutinous capsules, but also by the fact that these agglomerated masses, when they become detached, normally sink to the bottom of the containing vessel. It is thus, unless in cases of specially rapid sedimentation, practically impossible to be sure that a specific action is being exerted. Our personal experiences in the matter of the practical exploitation of the serum diagnosis of plague were extremely disappointing. We were quite unable to satisfy ourselves of the presence of specific agglutinating and sedimentary powers in the blood, either of plague convalescents or of persons who had been inoculated with Haffkine's plague vaccine. More than this, we were unable to satisfy ourselves as to the presence of any agglutinins in either of the two consignments of anti-plague sera which were kindly furnished by the authorities of the Pasteur Institute in Paris. In conformity with this, we are of opinion that no practical value attaches to the method of serum diagnosis in the case of plague.'*

* 'Report of Indian Plague Commission,' chap. iii., p. 68.

As far as uncomplicated bubonic cases are concerned, it would appear that a more favourable prognosis may reasonably be expected if the cases be taken in hand early. The mortality among such, when treated in railway plague medical inspection camps, has been unusually low as compared with similar cases treated in hospitals; this, conceivably, is because most of the former were removed from trains while only in the incubation stage, and received treatment from the beginning of their attacks Complicated cases, however, and those without primary external buboes, have shown as high a rate of mortality in these camps as in hospitals

There can be no doubt that the sanitary conditions amidst which people dwell and become infected influence the mortality-rate in a remarkable way. Professor Fraser* cites the following striking instance to illustrate the relationship between air pollution and the virulence of the plague. Of three groups of patients in Bangalore, one group consisted of plague contacts, who, on becoming affected in the well-ventilated segregation camp, were removed to plague hospitals, the second group consisted of plague patients who became affected in the city,

* Appendix iii. to 'Report of the Indian Plague Commission,' p. 485.

right axillary, right femoral, and right inguinal buboes respectively.

As has been seen, multiple bubonic cases are not necessarily more dangerous than single ones as long as the cases remain bubonic, and the extension of the infection is by the lymphatics alone; but, when secondary infection of distant glands takes place by the infective agent entering the blood-stream, the cases, being septicæmic, are consequently much more fatal than single uncomplicated bubonic cases.

Bubonic cases in which there is extensive effusion are more fatal than those in which such is limited. It has been seen that effusion is generally more profuse and contains more blood in cases with pectoral and axillary buboes than in those with cervical or inguinal ones, and in such cases it has been known to involve the whole of one side of the chest, abdomen and back.

Most observers are agreed that case mortality is lower among Mohammedans than Hindoos, and among Parsis, Eurasians, and Europeans than among Mohammedans; but it is impossible so to eliminate, from available statistics, all possible sources of error as to fix any definite numerical ratio. It is, moreover, highly questionable whether there is a constant ratio.

limb in acute inflammation, sudden sharp rise of temperature during lysis, the *simultaneous* appearance of fresh buboes in remote parts, early and severe delirium, coma, supervention of secondary manifestations referable to other systems than that primarily affected, intense dyspnœa indicating œdema or hypostatic congestion of lungs, sudden extension of infiltration indicating probable hæmorrhage, and rapid falling-off in the volume of the pulse.

and were thereupon removed to hospital; and the third group consisted of plague patients who also became affected in the city, but were treated in their own homes. In the first group the mortality was 53·69 per cent.; in the second group it was 68·77 per cent.; and in the third group it was 97·06 per cent.

Available statistics are inadequate to lead to any definite conclusion as to whether plague is more fatal at any particular period of life than at others, or whether the mortality is higher in one sex than in the other.

Professor Fraser* considers it to be a distinguishing feature in the prognosis of plague that, usually, the period of suspense extends over only a few days; for nearly all who survive until the eighth day, rather less than four-fifths of those who survive until the fifth day, and more than half of those who survive until the third day, may be expected to recover.

Among the circumstances which enhance the probability of a fatal issue may be mentioned sudden crises, crises with hæmorrhage or severe diarrhœa, sudden involvement of the lymphatics of a whole

* Appendix ii. to 'Report of Indian Plague Commission,' p. 442.

pared and applied principally for the curative treatment of plague, but they are also capable of exerting a prophylactic influence, which, though only transient, has the advantage of being immediately produced. The former confer a more lasting protection, but it is generally believed that this does not commence until some days after the date of inoculation. It would appear advisable, therefore, as suggested by Professor Fraser,* that persons particularly exposed to infection should be afforded *immediate protection* by the injection of one of the sera, and more lasting protection by a subsequent inoculation with a vaccine. The latter alone is generally sufficient for persons not so exposed, and, wherever plague threatens or is raging, arrangements should exist for the inoculation of all who may wish to avail themselves of it.

The question of plague prevention by prophylactic inoculation will be fully considered in the chapter on measures for the suppression of plague. It is sufficient to say here that it is definitely established that the protection which it affords materially reduces the number of plague attacks among the inoculated, modifies the severity of such attacks as

* Appendix ii. to 'Report of Indian Plague Commission,' p. 443.

CHAPTER VII

TREATMENT

A. Prophylactic treatment: general and special—B. Curative treatment. (*a*) Medicinal; (*b*) General and hygienic; (*c*) Dietetic; (*d*) Local; (*e*) Treatment by anti-toxic sera.

A. *PROPHYLACTIC TREATMENT.*

As in the case of other specific disorders, prophylaxis naturally resolves itself, firstly, into the taking full advantage of any specific measure which may exist for immunizing individuals, and, secondly, into the avoidance of exposure to those factors which are known to be predisposing causes of plague.

With regard to the first of these, we have tried and proved specifics in Haffkine's and Lustig's anti-plague vaccines, and the sera of Lustig, Yersin, Roux, *Galeotti and others. The latter have been pre-*

the suppression of all causes which might lead to gross air pollution; and the latter by mechanical means.

B. CURATIVE TREATMENT.

(a) MEDICINAL TREATMENT.

The main indications for medicinal treatment which have been observed have included the necessity for elimination; for reducing temperature; for stimulation; for combating insomnia, excitement and other nervous manifestations, for counteracting the effects of the virus in the system; and for restoring the powers during convalescence.

In a disease like plague, the main characteristics of which are intense physical and mental prostration, the ordinary medicinal eliminants and antipyretics have to be employed with the greatest caution to guard against collapse In many cases they are entirely contra-indicated, and tepid or cold sponging, or the wet-pack, have to be relied upon for reduction of the temperature In cases in which it is considered advisable and safe to use them, they should be combined with agents which counteract their depressing effect by stimulating the nervous system and strengthening the circulation.

The employment of such latter agents is almost

do occur, and may abort the disease among those inoculated during the incubation period.

As regards the second or more general means of prophylaxis, the predisposing causes of plague have been fully dealt with in the chapter on Ætiology. A detailed consideration of these will indicate the surest means of avoiding individual infection, and of prevention of outbreaks in towns and villages.

Plague being, essentially, a disease of locality, and its persistence and fatality being largely due to insanitary conditions, our ultimate salvation lies in the direction of sanitary improvement in the places where it prevails. As has been seen, the so-called racial immunity which has, during the recent outbreaks, been enjoyed by Europeans, and those who live like them, is only racial to the extent that it depends on the gradual improvement in environment which organized sanitation has effected among them.

Plague cannot thrive in well-ventilated and well-lighted dwellings; nor does it gain a hold among those who live in the open air, or in camps, or on board ship The chief essentials, therefore, to secure immunity would appear to be pure air and light: the former can be obtained in dwellings by effective ventilation, the avoidance of overcrowding, and

the suppression of all causes which might lead to gross air pollution; and the latter by mechanical means.

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In a disease like plague, the main characteristics of which are intense physical and mental prostration, the ordinary medicinal eliminants and antipyretics have to be employed with the greatest caution to guard against collapse. In many cases they are entirely contra-indicated, and tepid or cold sponging, or the wet-pack, have to be relied upon for reduction of the temperature. In cases in which it is considered advisable and safe to use them, they should be combined with agents which counteract their depressing effect by stimulating the nervous system and strengthening the circulation.

The employment of such latter agents is almost

always indicated whether or not eliminants are required, especially those which act in the direction of strengthening the circulation, such as digitalis and strophanthus. These may be administered alone or in combination with strychnine. Professor Fraser* considers that the greatest success appears to have been obtained by the subcutaneous administration of a combination of strophanthus and strychnine, or by combining the administration of digitalis by the mouth with that of strophanthus by subcutaneous injection. Alcoholic stimulation is always desirable, but if there be much excitement and delirium, it should be combined with the bromides of sodium, potassium, or ammonium.

For combating insomnia and other nervous manifestations, practically all the known soporifics and sedatives have been tried; but it cannot be definitely pronounced that any have given universally better results than any others; personal element and individual idiosyncrasy largely affect the question, for what has suited some has entirely failed with others, and it is only by the exhibition of several in succession, when the first fail, that we can discover the most suitable for any individual case.

* Appendix II. to 'Report of Indian Plague Commission,' p. 445.

The administration of antiseptics with a view to counteracting the baneful effects of the virus within the system has been largely resorted to. The principal agents employed have been mercuric chloride, carbolic acid, permanganate of potash, and iodine terchloride. The combined results of the experiments, however, do not justify the hope that future application of the principle is likely to be attended with success As pointed out by Professor Fraser, 'An objection to the employment of medicinal substances for this purpose is found in the absence of restriction of action upon the *causa mali*, and a consequent dissipation of power in unwished-for directions; for the most efficient of them equally affect and combine chemically with many of the ordinary constituents of the body, and thereby fail to be present in their originally active condition in sufficient quantity to produce an appreciable destructive action on the virus, unless very large, and therefore poisonous, doses are administered '*

The injection of these and other antiseptic agents into the substance of buboes in cases in which the virus had presumably not entered the circulation has also been attempted, but with doubtful success,

* Appendix II to 'Report of Indian Plague Commission,' p. 444

except to the extent that it may have hastened suppuration in the buboes. Surgical interference with a bubo before suppuration (and the consequent probable death of the bacilli) is, moreover, open to the objection that it may facilitate the entry of the infective agent into the circulation. As will be seen later on in the course of this chapter, however, the injection of anti-toxic sera into buboes, before diffusion of the virus, is a plan which is likely to produce better results.

For restoring the powers after an attack, the medicinal treatment should naturally be designed to meet the most prominent indications in individual cases. Nervine tonics and hæmatinics, either separately or combined, are most commonly called for, and they should be continued long after the establishment of convalescence, especially in cases with chronic suppurating buboes or indolent ulcers.

(*b*) GENERAL AND HYGIENIC TREATMENT.

It is essential that plague patients should be kept absolutely at rest, not only during the acute stage, but till well after the establishment of convalescence. Owing to the particular action of the virus upon the heart and circulation, sudden exertion is apt to lead to fatal syncope.

They should be treated in well-ventilated and well-lighted apartments; overcrowding should be prevented, and every precaution adopted for the suppression of any other circumstance likely to cause pollution of the air.

As has been seen, plague bacilli may continue to be thrown off in sputa and other products for prolonged periods after the establishment of convalescence It should therefore be borne in mind that some convalescent patients, and especially those in whom pulmonary plague symptoms may not have entirely disappeared, are dangerous sources of infection.

(c) DIETETIC TREATMENT.

In order to support the powers, food should be administered in small quantities at frequent intervals. The food should be of a readily assimilable nature, and at the same time nourishing—*e g*, farinaceous gruel with milk, or beef or chicken tea. Solid food should never be given during the acute stage, nor should the quantity of even liquid nourishment be ever sufficient to throw a heavy task upon the digestive organs.

(*d*) LOCAL TREATMENT.

Surgical interference with buboes, as has been seen, is generally undesirable before the establishment of suppuration. In the early stages hot fomentations, ice-bags, and other sedative applications, afford much relief. On the appearance of suppuration, however, free incisions are called for, the wounds thus caused being, after evacuation of the contents of the buboes, dressed with anti-septic precautions. It would appear that the streptococci in pus starve the plague bacilli, and thus put an end to their existence. Free incision after suppuration is, therefore, not likely to permit of the escape of any bacilli into the blood-stream, as would probably happen were incision to precede the destruction of the bacilli. Necrosis of skin, gangrene, pulmonary or gastro-intestinal symptoms, plague-boils, and other complications and sequelæ must be treated on general principles as they appear.

(*e*) TREATMENT BY ANTI-TOXIC SERA.

There can be no doubt, on theoretical grounds, that a specific disease is best treated by what will render its particular virus innocuous. As far as plague is concerned, judging from the encouraging

results which have been obtained by therapeutical experiments with the serum of immunized animals, there is a very reasonable hope that a substantial reduction in mortality from this disease may be confidently looked for by this method of treatment It would appear that the sera hitherto employed have lacked anti-toxic and anti-bacterial power; and, as pointed out by the Indian Plague Commission,* the imperfections of the present methods of preparation and application should be fully recognised; the line of progress lying, not in the direction of applying the sera at present available to the largest number of patients, but in that of studying, in the case of animals who furnish the serum, the blood changes which are associated with the incorporation of the plague toxins, and with the elaboration of antidotal and bactericidal substances.

Professor Fraser† considers that, in cases in which the infective agent is concentrated in buboes (preliminary to diffusion through the body), even sera such as have hitherto been used, if brought directly into contact with it by injection near or into the substance of the buboes, would be likely to exert an

* 'Report of the Indian Plague Commission,' p 320.

† Appendix ii to 'Report of the Indian Plague Commission,' p. 445.

energetic action, though inert if required to extend their action by diffusion through the body to the tissues and fluids.

It is manifest, however, that only sera with very *strong anti-toxic* and *anti-bacterial* properties can exert any influence after diffusion of the infective agent throughout the body, as, before exerting their anti-toxic and anti-bacterial actions (which are strictly quantitative chemical combinations), they have to act, primarily, by dissociating the toxic and bacterial elements with which they are to combine from the body protoplasm, the energy necessary for this disruption being proportionately greater as the elements to be dissociated are more virulent, or possess greater resistance to the destructive forces in the body.

We are reminded by the Indian Plague Commission* that a more formidable obstacle to the effective therapeutic exploitation of anti-bacterial *substances than even the difficulties which* are associated with the production of potent anti-bacterial sera exists in the conditions which must be satisfied before such disruption can occur. The anti-toxic and anti-bacterial substances must pass

* 'Report of the Indian Plague Commission,' chap. v., p. 273.

into the blood, and thence into the lymph; the *lymph*, which has thus acquired anti-bacterial qualities, must pass in a *continuous* stream through the organs or tissues which harbour the invading bacteria; and the therapeutic efficacy of the anti-bacterial substances can make itself felt only in cases in which the mass effect which is achieved in the poisoned tissues is adequate to bring about the desired disruption in the bacterial protoplasm

The anti-bacterial substances in freshly-drawn-off sera are of two kinds (1) specific, which are stable, and (2) non-specific, which are unstable. The latter are unable to resist exposure to sunlight or a temperature above 55° F., and die spontaneously in varying periods after the serum has been drawn off; they act indiscriminately on all bacteria, and by some it is believed that it is they which alone are really active, and that they exert an action similar to that of the digestive ferments, the specific ones merely bringing them into chemical relation with the bacteria. But, on the other hand, as suggested by the Indian Plague Commission,* 'it is possible that the added effect which is obtained when non-specific anti-bacterial substances operate in conjunction with

* '*Report of the Indian Plague Commission*,' chap. v., p 273.

the specific anti-bacterial substances may be attributable to the continued effect of disruptive forces coming into operation upon the bacterial protoplasm simultaneously in opposite senses.'

The sera which have been employed are those prepared after Yersin's method, or the immunization of animals by repeated injections of dead or living bacilli; and those obtained by Lustig's method, or the subjection of animals to repeated inoculations of a nucleo-proteid obtained from the bodies of plague bacilli by first treating them with a solution of caustic potash (which disintegrates and dissolves them), and then adding acetic acid, which throws down the derivative in the form of a white precipitate which changes, on drying, into a brown amorphous mass.

Sera thus obtained were tested by the Indian Plague Commission with a view to determining the presence in them of anti-bacterial substances. The methods they employed were: (*a*) The mixing of the sera and the bacteria against which they were to be tested *in vitro, for ascertaining whether the* morphological structure or disposition of the bacteria was in any way altered by the serum; (*b*) the cultivation of the bacteria on the sera; (*c*) the introduction of the sera, with a measured quantity

of the corresponding bacteria, into the peritoneal cavities of normal animals for testing the presence or absence of specific anti-bacterial substances by examining portions of peritoneal fluid, withdrawn at different intervals, with a view to ascertaining whether the incorporated bacteria had been spherulated or dissolved; and (*d*) the testing of the therapeutical result of the sera on animals infected with plague.

The results of the first three methods are thus recorded: 'In the case of the samples, both of Yersin's serum and of Lustig's serum, which were examined by us, we were quite unable to detect anything in the nature of agglutination or morphological alteration in the plague bacteria which were brought in contact with the diluted or undiluted serum. These observations, however, are not conclusive as to the absence of agglutinins, for, as explained elsewhere, the presence of agglutination can hardly be demonstrated with cultures such as those we were using, in which the plague bacteria are already *ab initio* agglomerated together.

'Further, we were unable to satisfy ourselves by cultivation methods of the presence of any anti-bacterial substances in the serum. Plague bacteria were cultivated on Yersin's and Lustig's serum and

on mixtures of those sera and ordinary nutrient broth; and these cultures were, so far as could be judged, no less luxuriant than those which were made upon normal horse serum and nutrient broth respectively.

'Further, we added the serum in different proportions to fresh cultivations of plague bacteria, and we inoculated these mixtures into the peritoneal cavities of normal guinea-pigs, with a view to determining whether the serum would, in presence of the non-specific anti-bacterial substances which are contained in the normal peritoneal fluid, exert a spherulating or bacteriolytic effect. Here, again, our results were purely negative. We saw nothing which reminded us even in the remotest degree of the striking results which were obtained when cholera bacteria were introduced into the peritoneal cavity *in association with the serum which contains* the corresponding specific anti-bacterial substances.'*

As regards the last method, they report that 'the administration of Yersin's serum did, when administered to guinea-pigs, exert a well-marked effect in the direction of protection.' Though the injection of as much as 2 c.c. did not suffice to ward off a

* '*Report of the Indian Plague Commission*,' *chap.* v., p. 278.

fatal issue, they admit that the treatment deferred the time of death, held septicæmia in check, and operated in the direction of limiting and localizing the plague invasion.

As to experiments with Lustig's serum by the last method, their results are thus summarized. 'In the first series of experiments, in which four guinea-pigs—treated respectively with $\frac{1}{4}$, $\frac{1}{2}$, 1, and 2 c c of the serum—and two control animals were inoculated with exactly the same quantity of plague culture, the first to succumb was the animal which had received the largest dose of serum This animal succumbed on the second day Two days after this the controls succumbed, and along with them the serum animals which had received respectively $\frac{1}{4}$ and 1 c.c. Only one serum animal survived longer than the control animals. This animal, which had received $\frac{1}{2}$ c c. of the serum, survived till the seventh day.'

Of a second series of experiments in which four guinea-pigs received respectively $\frac{1}{2}$, 1, 2, and 4 c.c. of Lustig's serum, they report that all the animals succumbed twenty-four hours before the control guinea-pig.

These results are much less satisfactory than those obtained with Yersin's serum in a series of experi-

on mixtures of those sera and ordinary nutrient broth; and these cultures were, so far as could be judged, no less luxuriant than those which were made upon normal horse serum and nutrient broth respectively.

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* 'Report of the Indian Plague Commission,' chap. v., p. 278.

were, in the case of the earlier experiments, masked by the presence of non-specific anti-bacterial substances. In accordance with this suggestion, they think that 'the earlier and more favourable results would be explained as the result of the incorporation of the unstable anti-bacterial substances present in fresh sera, while the unfavourable results obtained in the later experiments would be explained as the result of the incorporation of an unneutralized residuum of the bacterial poison employed for the injection of the horses'

They* instituted two series of experiments for determining whether Lustig's serum contained toxic substances in quantity sufficient to kill normal guinea-pigs, but in neither was there any evidence of the presence of unneutralized poisons They do not think this result, however, inconsistent with the assumption that the serum may have contained small quantities of unneutralized plague poisons, such as would become evident when superadded to poisons in the infected organism. Analogous phenomena observed by Professor Fraser,† in connection with anti-venomous serum, and by Ehrlich, in

* 'Report of the Indian Plague Commission,' chap v., pp. 280, 281.

† *Ibid.*

ments at the Pasteur Institute, Paris,* and than those obtained by Galeotti† in his experiments upon animals with Lustig's serum. With regard to the former, the Commission‡ think that, if the difference in the result is not imputable to the larger test dose or superior virulence of the cultures which they employed, it may have been due to the absence of the unstable anti-bacterial substances in the sera employed by them (those employed in Paris being freshly drawn). As to the latter,§ they are unable to suggest any satisfactory explanation of the striking difference between Dr. Galeotti's results and their own; but as his experiments were with fresh sera, and theirs with those that had been standing for some ten days, they think it possible that the discordant results may be explicable (the same explanation has been put forward by Cobbett‖ to account for the discordant results which have been obtained by different observers with one and the same variety of anti-streptococcus serum examined at different times) by the assumption that the sera in question contained unneutralized poisons which

* *Vide* 'Report of the Indian Plague Commission,' chap. v., pp. 280, 281.

† *Ibid.*

‡ *Ibid.*, p. 280.

§ *Ibid.*, p. 281.

‖ *Ibid.*

patients treated by Captain Mason, R.A.M C, in Cutch, to be clinical evidence sufficient to raise a strong presumption that the course of the disease was favourably influenced by the exhibition of the serum.

'In the case of our own experiments, conducted with a serum derived from the Pasteur Institute, Paris; further, in the experiments of the German Plague Commission undertaken with a serum of similar derivation; and, lastly, in the case of the observations made by the Russian Plague Commission on the effects of the administration of a serum prepared in St. Petersburg, the patients appear not to have benefited in any way from the treatment. At the same time there was not in any of these three series of observations any indication that the serum had in any way aggravated the disease.

'In the case of the observations made by Mr. Haffkine with a serum prepared by himself, there appeared, on the contrary, to be a balance of advantage in favour of patients who were not treated with serum

'Lastly, to complete our summary of the effects of the administration of Yersin's serum, we may recall the fact that in the case of a quite considerable

connection with milk drawn off from a goat which had a few days previously received an injection of tetanus toxin, are quoted by them; and they give one more possible explanation of their results in the probability that the serum contained *anti-bactericidal* substances similar to some described by Wright in an anti-typhoid serum examined by him. It should be added that the Commission confined their experiments with Lustig's sera to animals, and did not in any case extend them to human beings. They record, moreover, that they did not come across any evidence that any unfavourable influence had been exerted when the sera were therapeutically administered to man.

From all the statistical records brought in evidence before them relative to the experiments upon human beings with these two classes of sera, they give the following summary regarding Yersin's serum:

'Except in the series of observations made by ourselves and by the Russian Plague Commission, nothing in the nature of a strict statistical comparison could be made between the case mortality of cases treated with serum and the case mortality of cases not treated with serum.

'There appeared, however, in the case of the patients treated by Dr. Simond in Karachi and the

Every alternate one of 206 admissions was placed in the serum group, the results among the remainder, or control group, serving for comparison. In this series only a very small percentage of gain, as compared with the above results, accrued to the serum group (numbering 104), in which 23 recovered and 81 died, 21 recovering and 81 dying in the control group (numbering 102)

All that can be pronounced at present, therefore, is that the results of the experiments are encouraging, and give grounds for hope that this system of treatment—the only rational one for a specific disease—may, by gradual improvements in the method of preparation and application of the serum, lead to a substantial reduction in plague mortality.

number of healthy persons inoculated *prophylactically* with Yersin's serum, such statistical results as were obtained were quite inconclusive on the question as to whether the fleeting protective effect which was expected was actually realized. It was, however, noted that in certain cases toxic phenomena, in the form of fever, pain in the joints, and swelling of glands, supervened upon the incorporation of the serum.'*

Regarding Lustig's serum, from three successive series of observations brought before them, they consider the results of the first two (which showed percentages of 18·7 and 11·5 respectively in favour of the serum treatment) to be inconclusive, owing to the method of selection of cases adopted; but that that of the third series (showing a percentage of eleven in favour of the serum treatment), where all possibility of *selection* was avoided by subjecting to the serum treatment every second patient who was admitted to the hospital, affords evidence of a diminished mortality on the part of the patients who were treated with the serum

A later series of observations with this serum was made during the winter outbreak of 1900-01.

* 'Report of the Indian Plague Commission,' chap. v., p. 319.

bubonic case, showing fall in temperature and pulse-rate, but rise in respiration-rate, before death.

Chart No. VI. is that of a septicæmic plague case with dysenteric-like stools. It shows sudden crisis

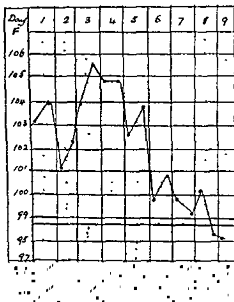


CHART I.—W., European · Left femoral bubo Resolution, recovery

following hyperpyrexia. The pulse-rate, though high, was uniform, but the respiration-rate, which was high throughout, rose considerably before death.

Chart No. VII. is that of a fatal case of primary

CHAPTER VIII

NOTES OF CLINICAL INTEREST

THE first four of the clinical charts included in this chapter are from among some interesting ones recorded by Lyons.* Chart No. I. is that of an ordinary uncomplicated bubonic case, showing recovery by lysis

Chart No. II. is that of a bubonic case complicated by hæmorrhage from the bowels, showing crisis and fatal result.

Charts Nos. III. and IV. are those of cases with left and right axillary buboes respectively, both complicated by secondary plague pneumonia, the former resulting fatally after repeated crises, the latter after sudden crisis following hyperpyrexia.

The four following are from among charts recorded by Meyer.† Chart No. V. is that of a fatal

* Report of Major Lyons, I.M.S, President Bombay Plague Research Committee.

† Report of Major Meyer, I.M.S., on 'Plague Operations in Sholapur.'

bubonic case, showing fall in temperature and pulse-rate, but rise in respiration-rate, before death.

Chart No. VI. is that of a septicæmic plague case with dysenteric-like stools. It shows sudden crisis

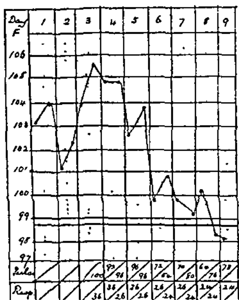


CHART I.—W., European. Left femoral bubo. Resolution, recovery.

following hyperpyrexia. The pulse-rate, though high, was uniform; but the respiration-rate, which was high throughout, rose considerably before death.

Chart No VII. is that of a fatal case of primary

plague pneumonia. It will be observed that the respiration-rate was inordinately high throughout.

Chart No. VIII. is that of a case of septicæmic plague with multiple superficial buboes, complicated

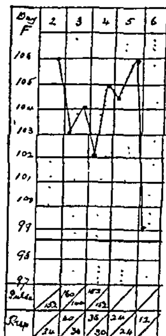


CHART II.—M., native Christian: Right femoral bubo; hæmorrhage from bowel. Crisis and death.

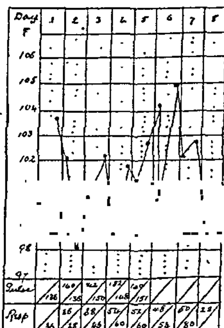


CHART III.—A. K. H., Mohammedan · Left axillary bubo; secondary pneumonia Repeated crises and death.

by secondary plague pneumonia. Death, it will be observed, was preceded by rise in pulse-rate and respiration-rate, but fall in temperature

Among notes of clinical interest reported by

Leumann,* the following may be cited, viz · *Seven cases of aphasia* (in patients who appeared to be in the early stage of a favourable convalescence), all uncomplicated by any actual paralysis of the limbs,

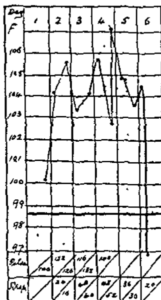


CHART IV —R. G., Hindu Right axillary bubo; secondary pneumonia, hyperpyrexia. Crisis and death.

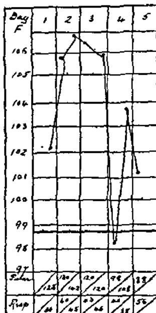


CHART V —A, native Christian. Left femoral bubo. Fall in temperature and pulse-rate, but rise in respiration rate, before death.

though all showed marked muscular prostration and weakness. Of these, one (a Mahratta female)

* Report of Captain Leumann, I.M.S., on 'Plague Operations in Hubli.'

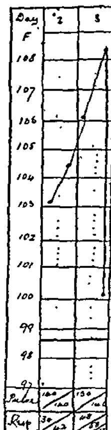


CHART VI.—M. P., Mohammedan. Septicæmic plague with dysenteric-like stools, showing hyperpyrexia and crisis. Pulse-rate uniform, but very high respiration-rate before death.

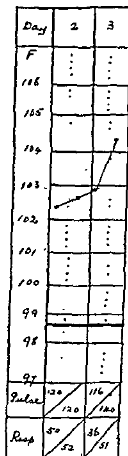


CHART VII.—N. B. C., Hindu: Case of primary plague pneumonia, showing inordinately high respiration-rate. Death

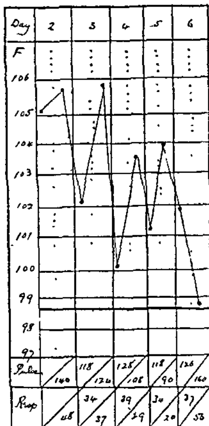


CHART VIII.—H. S., Hindu: Plague septicæmia with multiple superficial buboes, complicated by secondary plague pneumonia. Death preceded by rise in respiration and pulse rate and fall in temperature.

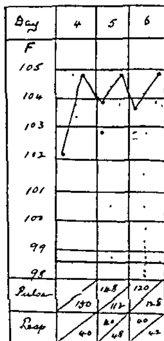


CHART IX.—V. N., 32, Hindu weaver. Plague septicæmia. Death.

died, and the other six (all males) recovered completely.

Two cases of paraplegia, and *two of hemiplegia* (*one right and one left*). These four cases all recovered completely.

Two cases of catalepsy (both males), one on the third day of the disease, and the other on the tenth day. In the former case the patient had been violently delirious for over twenty hours, and then appeared to be dead. On 'fixing' him, however, with his right arm at right angles to his body, the right index-finger pointing upwards, and his left arm flexed at the elbow, it was found that the former arm remained fixed for over twenty minutes, and the latter *for over seven minutes. In the latter case the* cataleptic state was less marked. In both, however, the pulse and respiration could only be made out with the greatest difficulty.

Thirteen cases complicated by pregnancy (two Europeans and eleven natives). Abortion or miscarriage occurred in all of these, and all the infants died. Only four of the mothers survived—viz., the two Europeans and two of the natives. Of the two natives who recovered, one was in the third and the other in the eighth month

One case pointing to infection through the placenta

(already noticed in Chapter IV., p. 90), in which a pregnant woman was attacked within two or three days of her full term. The child was born, apparently well, the mother dying of post-partum hæmorrhage Ten hours after birth, however, buboes appeared in the child's groins and axillæ, and it died in twenty-eight hours. On post-mortem examination plague bacilli were found in its blood, spleen, retroperitoneal, femoral, and axillary glands.

Sixty-one cases (also previously noticed in Chapter IV, p. 90) *among women suckling infants.* In connection with these, only twenty-four of the infants contracted plague. Of the remaining thirty-seven, fourteen died of diseases other than plague, and the remainder survived.

One case of acute septicæmic plague, uncomplicated by pneumonic symptoms of any kind, in which death was preceded by Cheyne-Stokes respiration.

And the following case of septicæmic plague published by him in the *Indian Medical Gazette*·

V. N., aged thirty-two, Hindu weaver. Admitted on fourth day of disease. For temperature, pulse, and respiration *vide* Chart No IX. Pulse soft and dicrotic. Presented all typical general symptoms of plague, and a bubo in left groin. On

fifth day he was violently delirious; the bubo was larger, and the left iliac glands swollen and tender. Towards evening he lay in low, muttering delirium, and wholly unconscious. On the sixth day he rallied slightly in the morning, and expressed himself as better, but soon relapsed into unconsciousness and delirium, and died at 4.30 p.m.

The following appearances were observed eighteen hours after death, when a post-mortem examination was held.

Rigor mortis marked. Several petechiæ on ocular and palpebral conjunctivæ and on mucous membrane of lips and gums. Large diffused bubo 3 inches by 2 inches in left Scarpa's triangle, surrounded by œdema, and apparently continuous with a bubo in the left iliac region. Mucous membrane of pharynx, larynx and œsophagus injected, with petechiæ in pharynx and larynx. Petechiæ on surface of both lungs in the visceral pleura. *Lungs* œdematous and bronchitic. Numerous hæmorrhages and petechiæ in the fold between the upper and lower lobes of both lungs and on their anterior surface. Hypostatic congestion at bases and back of both lungs. Frothy and muco-sanguineous exudation from cut surface of lung and in bronchi. Small hæmorrhages scattered throughout the lungs. *Heart*: About

1 ounce of fluid in pericardial cavity. Petechiæ on visceral pericardium, a few on parietal layer, at base of large vessels, and on anterior surface of left and right ventricles near the apex Muscular substance soft and œdematous. Right ventricle dilated and all cavities filled with ante- and post-mortem clots, the right cavities and large veins entering right auricle being loaded with tarry-looking liquid blood. *Intestines* much inflated Petechiæ on walls of ileum, jejunum, descending colon, and sigmoid flexure. On pushing aside the intestines, a large blood-stained, sausage-shaped mass, composed of numerous conglomerated glands, was felt along and surrounding the left iliac vessels Peritoneum covering this mass was infiltrated with sanguineous matter, thickened and covered with numerous small hæmorrhages. *Liver* enlarged and deeply congested, with large, irregular, stellate hæmorrhages spreading into its substance from effusions in its anterior, upper and falciform ligaments A pale-yellowish necrotic patch, irregular in shape, about 2 inches square, and extending about ½ inch to ¾ inch into the substance of the organ, was seen anteriorly, spreading from middle line into both lobes. On section liver was soft, bloody, and friable *Gall-bladder* embedded in a mass of hæmorrhagic matter, with two large hæmor-

rhages on outer surface; contained about 3 ounces of dark, viscid, bloody-looking bile. *Pancreas* showed a small irregular hæmorrhage over surface of its tail. *Spleen* enlarged to double the normal size, with two or three irregular hæmorrhages at its hilum; very soft on section and showing numerous infarcts. The whole organ was imbedded in bloody œdema, which had spread from below. *Kidneys:* Right kidney showed a small dark-red clot in pelvis, but was otherwise normal; left kidney embedded in bloody œdema, extending all round it, penetrating capsule, but not substance. Small hæmorrhage in upper part of capsule. *Ureters:* Right, normal; left, swollen to twice the size of right, dark red in colour, and lying deep in the bloody extravasation along left flank. *Suprarenal bodies:* Right, natural; left, slightly hæmorrhagic on surface and on section, and swollen to twice the size of the right one. *Stomach* dilated. Numerous hæmorrhages externally along greater curvature. Coats œdematous and thickened, mucosa showing prominent injected ridges, with numerous petechiæ of all sizes irregularly scattered from cardiac to pyloric end. *Lymphatic system:* Hæmorrhagic mass 2 inches × 3 inches × 2 inches in left Scarpa's triangle embedded in much sero-bloody œdema, entirely surrounding femoral vessels.

The mass consisted of several large glands irregularly engorged with blood and fusing above into extravasation, which extended through Poupart's ligament to the left iliac fossa and up along the left flank as far as the spleen, enveloping everything in its course. The left iliac glands were enlarged and engorged, and lying on the iliac vessels, the walls of which were engorged, the engorgement of veins extending to their intima The peritoneum over the glands was also deeply blood-stained, the staining having passed deeply into the pelvic fascia and along the left lateral ligament of the bladder, infiltrating and involving all the glands and other structures in its course The right femoral, inguinal and iliac glands were slightly enlarged and hæmorrhagic, but the vessels appeared normal. (The left spermatic cord was also involved in the general œdema around the glands, and thickened to twice the size of that on the right It was not infiltrated with hæmorrhage, and the testicle was normal.) The retroperitoneal glands on both sides were enlarged and engorged, more on the left than on the right, spreading in places completely around the aorta and inferior vena cava. Hæmorrhage from the substance extended in these spots throughout the coats of the vena cava and into the outer coat

of the aorta. The mesenteric glands were slightly enlarged, and all appeared to be hæmorrhagic both on surface and on section. The left pelvic glands were affected in the same way as the left iliac, and continuous with them. The mediastinal, bronchial and other glands, both superficial and deep, were markedly hæmorrhagic throughout. The spleen, heart's blood, left inguinal and other glands, contained crowds of plague bacilli.

Chart No. X. is that of a case treated by Dr. Turkhud.* The patient was a Hindu female, aged eighteen, who was attacked with plague during the eighth month of her pregnancy. In spite of a miscarriage on the fourth day, she made an uninterrupted recovery, and became convalescent on the tenth day. On about the forty-fifth day, however, just as she was about to be discharged, she caught a chill which, in her weak state, led to pneumonia and death on the fifty-sixth day.

In illustration of the fact that one attack of plague does not always confer immunity from subsequent attacks, among others, are the following two cases published in the 'Report of the Bombay Plague Committee for 1896-97' (p 151): The first case,

* 'Annual Report of the Municipal Commission, Bombay, 1900-01,' p. 177.

Mrs E., was first attacked in Hong Kong on June 24, 1894, and again in Bombay on December 6, 1896. The second, M. A. H., was first attacked on September 30, 1896, and again on December 2 of the same year. Both patients survived the second attack.

Thomson* also records two cases in which one had

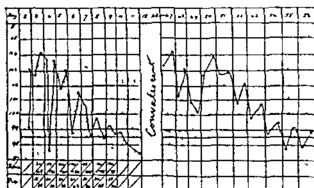


CHART X.

a second and fatal attack, and the other a relapse. Of the first he writes 'the second attack was in a woman aged forty; convalescent eighteen days; attacked twenty-seven days after the initial symptoms of the primary attack, and died five days

* 'Report of Bombay Plague Committee for 1896-97,' p. 51.

afterwards. The primary attack lasted nine days, and the fatal one five days, and in the latter she developed a fresh bubo in a different site from the original one, had fever, delirium, stupor, coma, and unconsciousness. The general characters of an acute attack were present in the tongue, pulse, respiration, skin, eyes, intestinal canal, typhoid state, and mental condition. Her temperature had been normal eighteen days when the fatal attack came on.'

Major Manser, I.M.S., first President of the Bombay Plague Research Committee, fell a victim to plague pneumonia, contracted in the course of his investigations His symptoms are thus detailed by Childe, who attended him. 'He was in his usual health on January 2, 1897, and had a sudden rigor in the morning, and felt fever coming on. During the day a bad headache developed; he felt nausea and vomited several times, and he had pains and a tired feeling in his limbs; his tongue remained clean and moist, and his skin was slightly moist. At 2 p.m. temperature 103·4°, pulse 116, respirations 25, and there were but slight variations during the day. On January 3 had passed a bad night and felt worse, and all the symptoms persisted, except the aching in the limbs, and he felt very ill. The

temperature remained between 103·5° and 104·5,° pulse about 110, and respirations 23 throughout the day. During the afternoon he felt some pain at the lower part of the left axilla, just under the anterior fold, but there was no glandular enlargement or pain in the glands anywhere On January 4 had passed a bad night and felt very ill. Temperature 104·6°, pulse 113°, respirations 25°; tongue still moist, with a little fur behind, and no sordes about the lips or teeth; the other symptoms as before. During the night he began to cough, and brought up some watery sero-mucous fluid, slightly blood-tinged, and the pain remained in the same place, only more diffused now, being felt over an area of a square inch. At this part some moist sounds could be heard, like those of early pneumonia, and they also could be heard just below the left clavicle; the rest of the lungs and other organs appeared to be normal, as did the lymphatic glands Patient considered that he had pneumonia, but the symptoms were not like ordinary pneumonia for the onset was different, the condition of the tongue and mouth different, there was no dyspnœa or pneumonic disproportion of pulse and respiration, and the sputum was not at all like rusty sputum, for it was loose and free, coming up with the slightest

cough; it was watery, looking more like serum than mucus, and it was slightly pink, not rusty-yellow at all. Also there was the striking fact that the patient's general condition was far worse than could be explained by the small amount of lung disease present. So I examined the sputum under the microscope, and found it full of bacilli looking like those of plague, and cultures were made from which a pure growth of the plague bacillus was obtained. During the 4th and 5th patient became steadily worse; his temperature remained about 104°, and his expectoration became most profuse; the moist sounds were heard over a larger area, as well as slightly at the bases; the respirations increased to 35, and then to 45, and the pulse to 120 and 125; and he ultimately died early on January 6.'*

Nurse Joyce,† who attended Manser, died of a similar form of plague. She fell ill on January 7, showed symptoms of pneumonia on the 8th, rapidly became worse, and died on the 10th. 'But,' writes Childe, 'her sputum was not nearly so profuse as in the former case, and symptoms of exhaustion came on much earlier. She also had no glandular pain or

* 'The Bombay Plague,' p. 108: Appendix A to Major Childe's report.

† *Ibid.*,

enlargement whatever, and bacteriologically her sputum was exactly as described above.'

Clemow* records an interesting multiple bubonic case, in which a left axillary bubo first appeared. On the third day after admission a chain of small, hard, tender glands was felt in the right neck and along the anterior margin of the sterno-mastoid, and, on the same day, a similar chain of glands in the left groin. Three days later a fresh small tender swelling appeared in the right neck, and a chain of enlarged tender glands in the right groin, both above and below Poupart's ligament. Later on left cervical and submental buboes appeared. In this case all the enlarged glands in the right groin receded, while all those in other positions—namely, the right and left cervical, the submental, the left axillary, and left inguinal—suppurated

Also the following case,† viz. S. V., Hindu, male; admitted on third day (March 2, 1898) with a small, hard, tender bubo in the left axilla, and a small patch of necrosed skin on the anterior surface of the left forearm. This bubo slowly receded, and on March 8 a small tender bubo appeared in the left

* 'Report of the Bombay Plague Committee, 1897-98,' pp. 122, 123.

† *Ibid.*

groin. On the 10th a similar bubo appeared in the right axilla, and on the 11th a fourth below the right ear. The left inguinal bubo suppurated, and was incised on the 13th. Those in the axillæ and neck receded without suppuration. On the 23rd the left axillary bubo, which had nearly disappeared, became larger and painful, but it again receded without suppuration. On the 24th a very tender swelling of the left supra-trochlear gland appeared and rapidly suppurated, and was opened on the 25th. The temperature had remained persistently high, and there had been severe diarrhœa from the 4th to the 10th. Between the 4th and the 15th the prognosis seemed hopeless, but the patient rallied and improved slowly, being eventually cured completely.

Dr. Alice Corthorn* records the following case—in which, though the particular manifestations were mild, there was great mental excitement during the period of abatement of other symptoms—viz. : O. R., Hindu, female; admitted on March 2, 1898, with pyrexia and left inguinal bubo. She progressed favourably, the temperature falling to normal on the 7th. She then became maniacal, violent, and

* 'Report of the Bombay Plague Committee, 1897-98,' pp. 127, 128.

unmanageable, and had to be quieted by morphia. The same symptoms, but less marked, continued till the 12th, when she became quiet and rational, and made an uninterrupted recovery, the bubo undergoing resolution.

Among cases admitted to the Pathare Prabhu Hospital in Bombay, Dr. Velkar* draws attention to the remarkable fact that, of six persons of one family (all living together) attacked, five had cervical buboes, and the sixth a supra-trochlear one. The author came across a somewhat similar group of cases, in which four of a family had cervical buboes. One of these had extensive infiltration extending below the clavicles to the chest and into the axillæ

Besides the cases above noted in which the disease recurred, the following is recorded by Weir,† viz. C. T. (Bania); first attacked in February, 1897, and again after two months. The second attack was contracted by his nursing and almost living in the same house with a plague patient.

He also records‡ the case of a ward-boy in the Grant Road Hospital, who is supposed to have

* 'Annual Report of the Municipal Commissioner, Bombay, 1900-01,' p. 211.

† *Ibid.*, 1896-97, pp. 171, 172.

‡ *Ibid.*, pp 53, 172.

caught the disease and died by secretly drinking the dregs of stimulants administered to the patients.

Another patient* sent by him to hospital was a boy suffering from mycetoma of the foot. He had no indications of bubonic plague, except a peculiar look about the face and a furred tongue. There were doubts about the diagnosis at first; but, after a period of observation, the Russian Plague Commission made a culture from the foot and obtained plague bacilli. He afterwards developed an abscess in the liver.

Wilkins,† to illustrate the fact that *hospital* mortality from plague is much aggravated by the ignorance of the people in refusing to bring their sick to hospital *early*, records the case of one man who was admitted with the whole of an enormous cervical bubo extending from the left ear to the sterno-clavicular joint filled with maggots; of others with large sloughing glands; and of children with perforated corneal ulcers.

Somewhat similar to the case (authentically recorded) of a patient, in the seventeenth century, who recovered rapidly in spite of having swum

* 'Annual Report of the Municipal Commissioner, Bombay, 1896-97,' pp. 53, 172.

† 'Report of the Bombay Plague Committee, 1896-97,' p. 225.

across the Thames while delirious, Surgeon-General Bainbridge* records the case of a patient who jumped into the River Indus and made a good recovery after being rescued.

The following incident, in a case under the author's observation, occurred at the Mahim Hospital in Bombay. The patient was a Brahmin, and, in delirium, had made several attempts to escape from hospital At about midnight, on a clear moonlight night, however, he jumped out of bed and ran towards the sea with great speed; but *for being tripped up and entangled in some weeds* on the beach he would have been drowned, as the tide was high and the wave-current strong. Before he recovered himself he was caught and taken back to hospital, and made a fairly rapid and uninterrupted recovery

The relatives of another patient of the author's surreptitiously brought him a plate of curry and rice, thinking his recovery was being retarded by insufficient nourishment He ate a hearty meal, and died soon after from failure of the heart's action, thus affording an illustration of the great danger of throwing a heavy task upon the digestive organs before complete recovery.

* Report on the Plague in Sinde, 1896-97.

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rely for the suppression of plague. Complete success cannot, however, attend their application unless such is effected under rules framed in strict conformity with the principles of modern hygienic science.

That complete success has been achieved when they have been so applied is evidenced by the rapidity with which the recent outbreaks were stamped out at Vienna, Liverpool, Glasgow, and, to a less extent, at Oporto.

It may be advanced by some that the adoption of the measures in Oriental countries must of necessity be deferred until a slow process of sanitary reform shall have resulted in placing such countries on the same footing, hygienically, as those in Europe. This, however, is by no means so. The introduction of certain main essentials upon which their success depends ought not to be a matter of great difficulty; and these should obviously include such means of getting to a knowledge of the earliest cases as the *compulsory notification of all cases of infectious disease*, and an *efficient system of registration of deaths.*

With these two safeguards suppression of an outbreak becomes possible, even in an insanitary town or village, but without them it is impossible amid the most perfect sanitary surroundings.

During the recent outbreaks various devices have

CHAPTER IX

MEASURES FOR THE SUPPRESSION OF PLAGUE

General remarks—Methods of suppression: (*a*) Preventive inoculation—(*b*) Isolation of the infected—(*c*) Segregation of the probably infected—(*d*) Disinfection of houses—(*e*) Disinfection of clothing and other articles—(*f*) Disinfection of the person—(*g*) Evacuation of dwellings—(*h*) Destruction of rats.

THE measures ordinarily adopted for the suppression of outbreaks of epidemic disease, of what nature soever, are isolation of the infected, segregation of the probably infected, disinfection of infected clothing and other articles, disinfection of houses which are fit for further human habitation, destruction of grossly contaminated articles, demolition of houses unfit for further human habitation, and removal of the inhabitants of infected localities to healthy surroundings.

It is upon these measures that we should *mainly*

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During the recent outbreaks various devices have

been resorted to for the discovery of cases. Such have included search-parties for house-to-house visitation; volunteer agencies (representing communities) for inquiring and reporting; surveillance of persons from infected quarters; rewards to persons reporting cases; a system of paid informers, etc.

The Indian Plague Commission,* in drawing conclusions as to the relative value of such measures, consider that house-searching can never be made popular, and therefore cannot be efficient unless with very strong establishments and a very limited amount of infection to deal with; but that by employing volunteer agencies as intermediaries between the people and the executive the risk of concealment is lessened, as is also the danger that the requirements of the authorities may be misunderstood.

They think that surveillance may often have been of use in deferring, though not in preventing, an outbreak; and that, notwithstanding the impossibility of taking absolutely effective precautions to prevent persons from infected parts surreptitiously taking up their abode in uninfected parts, it is one of the most useful means of preventing a healthy place from becoming infected.

* 'Report of Indian Plague Commission,' chap. vi., sect. ii.

As regards the payment of rewards to persons voluntarily giving information, they believe that experience of the system is strongly in its favour, but that the employment of paid spies or informers is a measure to which there are decided objections.

These views are in accordance with the opinions of all who have had extensive experience of the measures; and it is sufficiently established that, though they may be, to a certain extent, helpful, they cannot be relied upon, even when employed collectively, for bringing all cases to light. As, moreover, most of them can only be put into force when it is known or suspected that infection has been introduced, they cannot materially conduce to suppression, seeing that the earliest cases have escaped detection

What is obviously required, therefore, is a permanent system which shall secure that all cases of infectious disease, or suspicious cases, shall at all times be brought to light This can only be effected by the adoption of compulsory notification combined with an efficient system of registration of deaths

Compulsory notification can only be enforced by the infliction of a heavy penalty upon defaulters, not only the medical attendants, but also the relatives of the patients, being liable. In their

report* the Indian Plague Commission argue that, even where the failure to report cases renders the relatives or medical attendants liable to punishment, the prospect of being punished is too uncertain to weigh against the certain inconvenience that must result from coming forward to make a report. *There is no reason, however, that the prospect* of being punished should be at all uncertain, nor that the prescribed punishment should not be powerfully deterrent, including even liability to a term of imprisonment. Evasion would, moreover, be rendered very difficult by the obligation to report even *doubtful* or *suspicious* cases, and by combining with the system an *efficient scheme of death registration.*

No scheme of death registration can be perfect unless it furnishes information in respect of the *causes* of deaths as well as of the *numbers.* This information can only be obtained, in the absence of reliable death-certificates, by post-mortem examinations or an inspection of corpses. Such measures are seldom called for in European countries, as most deaths are properly certified; but in India, while only a very small proportion of death-certificates are reliable, it is believed to be generally very

* '*Report of Indian Plague Commission*,' chap. vi., p. 327.

repugnant to the feelings of the different classes to have the bodies of their dead, and especially those of females, exposed for inspection or post-mortem examination. This difficulty has therefore to be overcome, and the best way of doing so at present would be to assume at all times, that all deaths are due to infectious diseases, unless satisfactory credentials be forthcoming, or unless the relatives be willing to permit of inspection of the corpse or post-mortem examination.

Not only would efficient registration be by such means secured, but the people would be stimulated to efforts for obtaining reliable credentials, and customs which would compare favourably with Western practices might confidently be looked for within considerably less immeasurable distance than by waiting for a gradual system of evolution.

With such certain means of getting to a knowledge of the earliest cases of infectious disease, our measures of isolation, segregation, disinfection, and evacuation, would become powerful weapons in suppressing an outbreak of plague, and, by being effectual and of limited application, would seem less formidable than when applied on a large scale with only partial success.

It is freely admitted that a powerfully antago-

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* 'Report of Indian Plague Commission,' chap. vi., p. 327.

(α) PREVENTIVE INOCULATION.

Prophylaxis by the injection of Haffkine's anti-plague vaccine, a *sterilized* broth culture of plague bacilli, has been employed on a large scale for several successive years, and with conspicuously successful results

The system is an extension of the principle of preventive inoculation, which led Pasteur to employ *attenuated* bacilli as a vaccine against anthrax, in the same way as the latter was an advance upon the method of transferring *active* bacilli from infected to healthy persons.

The earliest inoculations with *sterilized* cultures were made by Wright* against typhoid fever, and soon after him by Pfeiffer and Kolle† against the same disease.

In 1895 Yersin, Roux, Calmette and Borell‡ demonstrated that the injection of *dead* plague bacilli conferred a certain degree of immunity in the case of rabbits and guinea-pigs, but to Haffkine is due the extension of the system to human beings.

* *Lancet*, September 19, 1896; *British Medical Journal*, January 30, 1897

† *Deutsche Medicinische Wochenschrift*, November 12, 1896.

‡ *Annales de l'Institut Pasteur*, 1895.

nistic factor to the success of the measures exists by rats being so important an agency in disseminating plague in a locality, and carrying it from infected to adjacent healthy localities. But it must not be lost sight of that the weapon which we possess in the shape of preventive inoculation for immunizing the people, before rats can spread the infection to any extent, constitutes a valuable compensating advantage.

METHODS OF SUPPRESSION.

Thus, in addition to the ordinary measures for combating epidemic diseases generally, we have, in the case of plague, the means of immunizing the people, and the necessity for organizing a campaign against rats. Taking the different methods of suppression in detail, they will be best considered under the following headings:

(*a*) Preventive Inoculation.
(*b*) Isolation of the Infected.
(*c*) Segregation of the Probably Infected.
(*d*) Disinfection of Houses
(*e*) Disinfection of Clothes, etc.
(*f*) Disinfection of the Person.
(*g*) Evacuation of Dwellings.
(*h*) Destruction of Rats.

would appear that Haffkine considers that the injection of both elements is necessary, on the assumptions that, while the bacterial sediment wards off attacks, it does not modify their severity; that the supernatant liquid gives one attacked a better chance of recovery; and that the best composition of the vaccine is secured when the elements are present in the proportion in which they are obtained in the process of manufacture.

He bases these assumptions on the fact that case mortality is not reduced with *anticholera* vaccine when the material for inoculation consists of cholera bacteria suspended in a mere watery menstruum. Apart from the fact, however, that what is true of cholera need not necessarily be true of plague, the experiments of Pfeiffer and Kolle* have led to the conclusion that the best results in the case of cholera are obtained by the inoculation of small quantities of perfectly fresh agar cultures.

Yersin, Roux and Borell† believe that no specific toxin is produced by the plague when cultivated in a liquid nutrient medium From experiments on

* Footnote on p 7 of article by Professor Bitter on Haffkine's 'Preventive Inoculation' in the *Zeitschrift für* [illegible]

[illegible]

chap. iv, p 192.

The vaccine is prepared by infusing mutton in hydrochloric acid at a very high temperature, straining, neutralizing the clear solution with caustic soda, adding oil or clarified butter (ghee), inseminating with active plague bacilli (preferably those obtained directly from fatal cases, or from cultures in which the virulence has been maintained by a series of passages through susceptible animals), sterilizing the resulting cultures at a temperature of 60° C. for an hour, and adding ½ per cent. of carbolic acid.

The addition of oleaginous matter is to enable the colonies to grow in stalactite form from the drops of oil floating on the surface, so as to obviate the retardation in growth which insufficient aeration in the deeper parts of the medium would entail; and the growth is allowed to go on till all the nutriment in the medium is consumed, by shaking down the colonies every few days, and leaving the floating drops free for successive crops of stalactites.

The vaccine, as issued for use. consists of liquid and solid elements, the former being the old nutrient medium with products of the culture *in* solution, and the latter the sterilized colonies. The relative value of these elements has been made the subject of detailed and careful inquiry. From his evidence before the Indian Plague Commission, it

peptone, which does not in any way add to the protective power, the immediate disagreeable results would be considerably reduced.

Both of the prescribed methods of standardizing different brews of the vaccine are liable to error. The first (which fixes the dose as equal to the volume necessary for producing an average temperature of 102° F. in a series of ten to twenty persons) because it is not practicable to keep the inoculated under sufficiently close observation for the time which is necessary for ascertaining the highest temperature occasioned by the reaction; and, even if it were, because the personal element so modifies the action of the same dose of any particular brew that it is rare to find the same maximum temperature in any two individuals, or the same interval of time between the hour of inoculation and the hour at which such maximum is reached. The second (which determines dosage according to the degree of opacity, as appreciated by holding samples up to the light) because it neither takes into account the virulence of the cultures, nor an estimate of the quantity of dissolved toxins, should any be present.

The want of a more reliable method may not materially have affected the utility of the vaccine,

monkeys,* the German Plague Commission consider that the whole protective power of the vaccine is resident in the bacterial sediment as distinguished from the supernatant fluid. Precisely similar conclusions were arrived at by the Indian Plague Commission† as the result of experiments on guinea-pigs; and they assert that, if there is any specific soluble toxin in the filtrate, it must be one which confers absolutely no protection against plague.

It does not, of course, follow that, because negative results have been obtained among animals, negative results must necessarily be expected among men; but it is extremely likely that what answers in the case of *different species* of animals *susceptible to plague* would also answer in the case of human beings were experiments upon the latter possible.

There is no doubt that several material advantages would be gained were it found possible to dispense with the supernatant fluid. The bulk of the material to be inoculated would be considerably reduced, to the great convenience of the operator and comfort of the person inoculated; and it is possible that by eliminating a large quantity of

* 'Report of German Plague Commission,' p. 336.

† 'Report of the Indian Plague Commission,' chap. iv., p. 193

fact that many of these qualifying circumstances may tell against as well as in favour of it.

The exact period for which the protection lasts has not been finally determined. It is certain that it extends over several weeks, and probable that it may extend over several months; but it is generally believed that any definite degree of protection does not begin until a few days after the date of inoculation.

No definite conclusion can be arrived at from available statistics as to the comparative efficiency of single and repeated inoculations. From the evidence brought before the Indian Plague Commission,* it would appear that in Hubli the protection was equal among the once and twice inoculated, in Dharwar and Gadag that the twice-inoculated were less effectually protected than the once-inoculated, and that in Damaun a second inoculation conferred considerable additional protection. The Commission consider that these divergent results can only be explained by the varying strength of the vaccine. On theoretical grounds, when, by reliable standardization, it will be possible to fix accurately the dosage of each brew, it might

* *Vide* 'Report of the Indian Plague Commission,' chap. iv, p 260

but such a method is desirable, because it cannot be overlooked that the injection of too much may cause unnecessary suffering; and of too little, insufficient protection. It stands to reason, moreover, that without accurate standardization it can never be established whether or not the protection, while it lasts, is absolute.

A true estimate of the advantages and disadvantages of the system should, however, be sought for, less from laboratory experiments than the results of actual practical application; and, while it can be safely asserted that there is no evidence on record to show that any serious ill consequences can be traced to inoculation with the pure vaccine thus prepared, careful analysis of the published statistics leaves no room for doubt that the protection which it affords materially diminishes the number of plague attacks among the inoculated, modifies the severity of such attacks as do occur, and may abort an attack among any inoculated during the incubation period.

It is true that in making such an analysis it is impossible to totally eliminate possible sources of error which might vitiate the statistics. Our estimate, therefore, of the real value of the measure can *only* be *approximate*, even *bearing in mind the*

adjunct to plague measures; and arrangements should exist for placing it at the disposal of all who are willing to avail themselves of it, especially of those who are particularly exposed to the infection and of those unwilling or unable to adopt other precautions.

Lustig's plague prophylactic has not received the same extended trial as Haffkine's, but, from several laboratory experiments for testing the relative value of different prophylactics (carried out in 1901 upon rats and guinea-pigs) at the Swiss Serum and Vaccine Institute in Berne, under the supervision of Professor Dr. Tavel, Director of the Institute, it is claimed for Lustig's preparation that, while being equivalent in value to Haffkine's in point of immunization, it has the advantages that it can be preserved for a longer period without deterioration, that the reaction is less severe, and that it is possible to give doses of an exactly measured quantity.

It is prepared by first inseminating broth with a two-days-old culture of plague bacilli on serum, then inseminating agar-agar with the broth culture, and adding a 1 per cent. solution of caustic potash to the agar-agar culture when three or four days old.

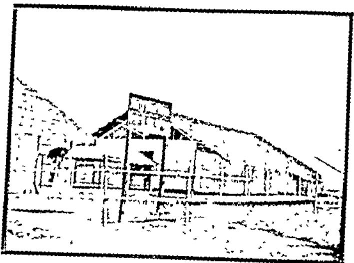
The caustic potash converts the culture into a slimy, filaceous mass from which, by the addition of

be assumed that the strong reaction following injection of the prescribed dose in one inoculation is likely to confer greater immunity than the mild reactions following two or more injections of partial doses.

Some observers have recorded that favourable results have accrued in the case of certain other diseases upon the use of Haffkine's vaccine ; it is remarkable, moreover, that the mortality from general causes among the inoculated of the Khoja community in Bombay and Karachi was observed to be extraordinarily low for some time after the dates of inoculation. It is conceivable that the reaction may, in a general way, stimulate to a healthy reaction in other disorders, on the principle that one disease often appears to influence the course of another ; but at present there is no evidence to warrant the assumption of any specific causal relationship on the part of the vaccine towards the phenomena which have been observed

Whether or not the protective power be absolute, it is established beyond doubt that inoculation saves many lives during the course of an epidemic, and, if applied on a large scale, exerts a powerful influence towards limiting its extent and duration by immunizing the people *It is therefore a most valuable*

PLATE X



TYPE OF TEMPORARY PLAGUE HOSPITAL. EXTERIOR VIEW

From Bombay Plague Committee Album compiled by Mr. F. B. Stewart, Photo Artist, Poona.

a 1 per cent. solution of acetic acid, a nucleoproteid from the bodies of the dead bacilli can be precipitated. This when dried and pulverized is issued for use in quantities of 0·04 gramme dissolved in 21 c.c. of soda solution, which is sufficient for three adult doses.

(*b*) ISOLATION OF THE INFECTED.

As has been seen, human beings under certain circumstances being powerful factors in plague *dissemination, it is of the highest importance that* the earliest cases should without exception be isolated.

The best method of isolation is undoubtedly that which is effected by removal to hospitals set apart for the purpose. It can rarely happen that this is not feasible; but should it not be so in any particular case, arrangements should be made for isolation in the best-ventilated and best-lighted room of the infected house. It must never be forgotten, however, that serious risks are incurred thereby.

If the earliest cases escape detection, and the infection becomes established in a place, isolation is valueless as a means of stamping out the outbreak, not only because it is impossible to isolate

PLATE XI



TYPE OF TEMPORARY PLAGUE WARD: INTERIOR VIEW.

From Bombay Plague Committee Album, compiled by Mr F. B. Stewart, Photo Artist, Poona

all the cases, but because attempts to evade the measure by removing the infected from house to house may result in the infection becoming more widely spread.

There is no doubt that the measure will never be a popular one, but its adoption need never be on any but a most limited scale; for if it be not applied to the earliest cases, it is far better to leave the infected alone, and, as suggested by the Indian Plague Commission,* palliate the evils that result therefrom by continual visitation of them in their houses, frequent disinfection of the infected rooms, and the encouragement of inoculation among other persons left in the houses.

(c) SEGREGATION OF THE PROBABLY INFECTED

The 'probably infected' naturally include all those who may reasonably be supposed to be carriers of infection, either in their persons or effects, on account of having been in contact with infected persons or their belongings, or from having been exposed to the same sources of infection which led those to contract the disease.

* 'Report of the Indian Plague Commission,' chap. vi., p. 338.

It is absolutely necessary that contacts of the earliest cases should be removed to segregation camps, and kept from mixing with the public until *all fear of their being likely to communicate* infection shall have passed. But when the earliest cases may have escaped detection, all hopes of the measure being effectual in suppressing the outbreak should at once be abandoned, and no further attempts at segregation attempted.

(*d*) DISINFECTION OF HOUSES.

Whether applied in the beginning of an outbreak or after the infection has spread, complete and thorough disinfection is a most valuable measure, and should always be resorted to in the case of houses which are fit for further human habitation. *Those pronounced by competent authority to* be obviously unfit, should be demolished, palliative measures being valueless in places which disinfectants cannot reach, or upon which it is impossible to bring desiccating influences to bear.

The maximum of benefit is derived when chemical disinfection is combined with evacuation for a month or more, and the opening up of the house to desiccating influences.

PLATE XII



TYPE OF TEMPORARY PLAGUE COT—WOODEN FRAME WITH LACED TAPE FOR LYING ON

From Bombay Plague Committee Album, compiled by Mr F B Stewart, Photo Artist, Poona

Many careful experiments have been conducted with a view to determining which is the cheapest chemical disinfectant, and its minimum strength for devitalizing the plague bacillus in conditions in which it exists in Nature. It is impossible, however, to obtain direct evidence of the efficacy of any particular one, because there is no known method of isolating the plague bacillus when in company with contaminating micro-organisms; and negative results, when trying to recover it from infected houses after disinfection, do not justify any definite conclusion.

Indirect experiments are therefore necessary, and these may either take the form adopted by Marsh,* of artificially introducing the bacillus into sterilized or unsterilized samples of floor material in such a way as to insure its recovery if it survives disinfection; or that, adopted by him and Hankin,† of disregarding the plague bacillus, and basing a calculation on the degree of reduction in the total bacteria in the floor; or that adopted by the Indian Plague Commission,‡ of estimating the value of any

* *Vide* 'Report of the Indian Plague Commission,' chap. vi., p. 358

† *Ibid.*

‡ 'Report of the Indian Plague Commission,' chap. vi., p. 361.

disinfectant by its power of destroying all but the more resistant forms.

The last would appear to be the method from which the most satisfactory results may be expected. The details of the system are as follows:

'Samples of the floor material which had undergone a disinfection process were collected. The samples, inasmuch as they were to serve only for the determination of the varieties of micro-organisms which might survive the disinfection process, were not measured in any way. What was actually done was to collect a little material by rubbing in each case a sterile cotton-wool plug, extracted with antiseptic precautions from a sterile test-tube, here and there over the floor or wall which was to be tested. This done, the plug was replaced, and the samples thus collected were conveyed to the laboratory. When the examination was taken in hand, a small quantity of each soiled cotton-wool plug was placed in a tube of nutrient broth. Care was taken to employ a relatively large quantity of this nutrient medium, so as effectually to dilute any disinfectant which might be carried over. This precaution having been taken, the tubes of broth were incubated for twenty-four hours. In cases where the tubes, after this interval, showed any signs of growth, isolated

colonies of the various bacteria were obtained. This was for the most part done by making zigzag cultures on agar. Pure cultures of any bacteria which survived the disinfection process having thus been obtained, graduated dilutions of the disinfectant which was employed in the disinfection process were prepared in a series of test-tubes As many series of such tubes were employed as there were species of bacteria to be tested. Into each dilution of the disinfectant was introduced a sufficiency of these pure bacterial cultures. After an interval of fifteen minutes, a loopful was taken from each solution of the disinfectant which had received a portion of the pure culture of the bacteria recovered from the disinfected floor. This loopful was transferred to a tube of nutrient broth which was incubated at the temperature of the room By this means information was obtained as to the capacity of the bacteria which were recovered from the disinfected floor for resisting the action of the disinfectant. This resisting power was then compared with the resisting power of the plague bacillus when subjected in similar manner to the action of the same disinfectant, and in cases where the resisting power of the last was found to be very distinctly less than the resisting power of each of the various

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The last would appear to be the method from which the most satisfactory results may be expected. The details of the system are as follows:

'Samples of the floor material which had undergone a disinfection process were collected. The samples, inasmuch as they were to serve only for the determination of the varieties of micro-organisms which might survive the disinfection process, were not measured in any way. What was actually done was to collect a little material by rubbing in each case a sterile cotton-wool plug, extracted with antiseptic precautions from a sterile test-tube, here and there over the floor or wall which was to be tested. This done, the plug was replaced, and the samples thus collected were conveyed to the laboratory. When the examination was taken in hand, a small quantity of each soiled cotton-wool plug was placed in a tube of nutrient broth. Care was taken to employ a relatively large quantity of this nutrient medium, so as effectually to dilute any disinfectant which might be carried over. This precaution having been taken, the tubes of broth were incubated for twenty-four hours. In cases where the tubes, after this interval, showed any signs of growth, isolated

occupied in such work would very soon possess a knowledge of the bacterial flora of the locality in which he worked, such as would enable him to judge at a glance of the efficacy of the disinfectant by noting the morphological characters of the bacteria obtained from the disinfected material.

Whichever be the best method, and though much speculation has arisen from the results of the numerous experiments, it is doubtful whether the problem has yet been solved as to which is the best disinfectant. The general conesnsus of opinion is in favour of mercuric chloride in a 1 in 1,000 solution, which should, in order to insure complete solution, be made up with hydrochloric acid or a soluble chloride.

To obviate the disadvantage of issuing the solution in bulk from central depots, a concentrated solution in acid of fixed strength should be issued in phials When required for use, this solution should be mixed with water up to the required strength To insure that the proper strength is employed, it is convenient to arrange that the quantities of the solution and water should be such as will quite fill vessels of a standard capacity, the same number of vessels of each being poured into an empty bucket or tub

species of micro-organisms which were recovered from the disinfected material, the disinfection was assumed to have been adequate.'

Liston* made a series of experiments, under the direction of the Commission, to determine by this method the adequacy of a 1 in 500 solution of mercuric chloride. It was found in one case out of seven that the material obtained from the paved or cemented floors which were tested was completely sterile. In the case of two other floors, the only growth that was obtained was of moulds. In that of four others the cultures gave bacterial growths. When the resistance of these last to mercuric chloride was tested, it was ascertained that the bacteria which had survived the disinfection were all (except in one instance, where one which was recovered was slightly less resistant) able to resist a fifteen minutes' exposure to a 1 in 1,000 solution of mercuric chloride. Plague bacilli treated in a similar manner in no case survived a like exposure to a 1 in 5,000 solution; the disinfections thus tested would therefore appear to be adequate.

The Commission foresee that a bacteriologist

* *Vide* 'Report of Indian Plague Commission,' chap. vi, p 361

former, *per se*, is not desirable, as it exerts no influence upon infective material in other parts of houses than the floors; and the latter should only be adopted in the case of mud huts or buildings so constructed as to render chemical disinfection difficult or impossible. For desiccation to be thoroughly effective, moisture-retaining material should be removed from the houses, and artificial openings made to admit of sunlight and free ventilation. It is not safe to permit reoccupation of such dwellings until desiccating factors shall have acted for ten weeks or more.

(*e*) DISINFECTION OF CLOTHING AND OTHER ARTICLES.

When it is possible to get at the earliest cases in an outbreak, thorough disinfection of the clothing and other effects of the infected persons, as well as those of the contacts, aids materially in suppressing the outbreak Even, however, when the earliest cases have escaped detection, and the infection has in consequence spread, this measure should not in the least degree be relaxed. Infected clothing is a most powerful factor in plague dissemination, especially as porous fabrics folded away in boxes are capable of retaining infection for a considerable

until the required quantity of the diluted solution is obtained.

Before applying the disinfectant, the room should be completely emptied. The solution should then be poured freely over the floor, forcibly pumped into corners, crevices, rat-holes, and other places which are difficult of access, and applied to the walls by mops or brushes. After free application it should be allowed to dry, and disinfection of the furniture, etc., in the manner which will be described, proceeded with.

Other chemical disinfectants which have been employed are carbolic acid, phenyl, lysol, permanganate of potash, nitric acid, hydrochloric acid, sulphuric acid, caustic lime and chloride of lime.

A summary of the results of experiments to test the effect of these agents upon the plague bacillus when suspended in inert media is published in the report of the Indian Plague Commission (chap. vi., pp. 354-357). These results demonstrate that oxidizing agents and acids are more active in devitalizing the microbe than reducing agents and alkalies.

In lieu of chemical disinfection, kiln burning of dug-up floors and simple exposure to desiccating factors have sometimes been resorted to. The

former, *per se*, is not desirable, as it exerts no influence upon infective material in other parts of houses than the floors; and the latter should only be adopted in the case of mud huts or buildings so constructed as to render chemical disinfection difficult or impossible For desiccation to be thoroughly effective, moisture-retaining material should be removed from the houses, and artificial openings made to admit of sunlight and free ventilation. It is not safe to permit reoccupation of such dwellings until desiccating factors shall have acted for ten weeks or more.

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period, either on account of their moisture-retaining qualities, or because of the difficulty of access of desiccating factors.

(1) *Clothing.*—Disinfection of clothing is effected either by boiling in water, by subjection to saturated steam under pressure, by soaking in disinfectant solutions, or by exposure to the direct rays of the sun. If the salt used for disinfection be perchloride of mercury, it should be in a neutral solution. Grossly contaminated articles should be destroyed by fire Fabrics, such as wool, silk, or leather, which would be injured or destroyed by boiling, steaming, or chemicals, should be spread out and exposed to the direct rays of the sun.

(2) *Furniture, etc.*—It is obviously necessary that all articles of furniture should be disinfected thoroughly before being replaced in houses which have been disinfected. This is readily effected by exposing them to the sun, washing them down with soft soap and water to remove grease, and then freely applying a 1 in 1,000 solution of mercuric chloride. In the case of cushioned chairs and sofas, it is generally desirable to remove and destroy the covering and stuffing, the wood and iron work being disinfected as above before restuffing and recovering.

Small articles which are of little value, and which may have been grossly contaminated, should be destroyed by fire.

(*f*) DISINFECTION OF THE PERSON.

Disinfection of the person by bathing in a weak disinfectant solution (phenyl or carbolic acid being the best) is desirable when removing persons from infected places to health camps, when permitting contacts to leave segregation camps, and when discharging plague patients from hospitals. Frequent bathing should also be enjoined on disinfectors, laboratory servants, corpse-bearers, ward attendants, and all who come into contact with plague patients or their effects.

(*g*) EVACUATION.

Experience has demonstrated beyond doubt that the prompt removal of the inhabitants of infected localities to healthy surroundings is a measure which conduces powerfully towards extinguishing an outbreak.

In order to obtain the best results from the measure, it is necessary that no time should be lost in getting the people out, that the effects of the evicted persons be thoroughly disinfected, that sufficient and suitable accommodation with arrangements

for isolation of fresh cases be available, and that the people be prevented from revisiting their houses (till permitted to do so) or to carry infection to neighbouring towns.

It is rarely possible, however, to maintain all these safeguards in actual practice. Unless the people have had previous experience of the value of the measure, it is difficult to remove them quickly, as they are disinclined to leave their household goods, and prefer the warmth of their dwellings to the uncertain comfort of camps, especially in cold or rainy weather. Suitable and sufficient accommodation cannot always be provided at short notice, nor can a large amount of disinfection be always arranged for within a limited time. If eviction means loss of employment, the persons so affected naturally migrate to neighbouring places and carry infection with them, it being practically impossible to control the movements of such if from large towns.

Were it possible, however, to arrive at a knowledge of the earliest cases in an outbreak, such difficulties would be very sensibly diminished, as the measure would only affect the inhabitants of the infected locality, and, by being on a limited scale, would be easy of application.

But even when the infection is established throughout a town, and the safeguards referred to above

cannot be maintained, it is better to evacuate than not. In actual practice it has been found difficult to carry out the measure efficiently in towns with populations exceeding 10,000 inhabitants, chiefly because the evicted cannot be properly controlled, and there is a danger of such of them as lose employment migrating to neighbouring places and carrying infection with them

As, however, fresh centres of infection thus created can themselves be extinguished by evacuation, it is highly probable that the plague would be more rapidly eradicated by evacuation than by being allowed to die out slowly in the original centre of infection, and to gradually spread therefrom to other places, as it would be certain to do.

(*h*) DESTRUCTION OF RATS.

Rats and mice being such important agents in plague dissemination, it is not only necessary that an organized scheme should be adopted for their wholesale destruction when plague threatens in a place, but also, as urged by Sutherland Fraser,* that the importation of rats from infected to healthy places should be prevented.

* Report by Dr. Sutherland Fraser on Disinfective Measures in Bombay City.

Tsukiyama,* the chief of the National Board of Health in Japan, considers that it is possible to exterminate the plague in infected cities mainly by destroying rats systematically. In support of this view, he points out that the plague was arrested in a few months in three cities, and was exterminated by a short application of the measure in the case of a fourth (Tainan) after it had prevailed for seven years. In the last town, in 1897, of every thousand inhabitants eleven contracted plague; in 1899 thirty-two, in 1900 twenty-four, and in 1902 only $\frac{1}{12}$ per thousand; during 1902 over 80,000 rats were destroyed.

The most satisfactory way of destroying them is by the employment of professional rat-catchers to trap them, or the payment of a small reward per rat to private individuals for doing so. All rats thus caught should be killed and their bodies destroyed by fire. A spring trap is generally found to be the most useful kind. The plan adopted in Japan is simple and effective. A small bowl is inverted on the ground, one side being slightly raised by resting the edge on a piece of cake or other suitable bait; a larger bowl is placed over this in such a way that one side rests on the ground and the opposite on the

* *Vide* article in *Sei-I-Kwai*, 1903, p. 198.

convex surface of the smaller one, just above the bait. When the rat nibbles the bait the smaller bowl totters, and the larger slips to the ground, imprisoning the animal.

Trapping should be supplemented by poisoning, the most suitable poisons being arsenic and phosphorus. Virulent cultures of the *Bacillus typhi murium* (discovered by Dr. Danysz of Paris) have been recommended, and their employment has been attended with a certain measure of success. 'Dr Abel (*Annales de l'Institut Pasteur*, April, 1900) obtained cultures of the bacillus from Dr Danysz, and administered portions of them in the laboratory to grey and white rats, the result being that the animals died in from six to twelve days The necropsy showed enlargement of the spleen, swelling of Peyer's glands, partial necrosis of the liver, and the presence of the bacilli in all the organs Other rats were then fed with the livers and spleens of the first series, with an equally lethal effect. In this way the toxic action could be continued through six generations. The method was then practically used to destroy rats in some localities where they happened to be abundant, pieces of bread treated with cultures of bacilli being laid down. The localities selected were the premises of the municipal institution for

disinfecting, a large transatlantic steamer, stables accommodating from thirty to forty horses, the depot of the Custom House, and another large building used for storage purposes. The results presented considerable variety, being most effective in the stables, where the rats completely disappeared for one and three-quarter years. In the steamer and in the stores there was no apparent effect, whilst in the Custom House and in the municipal establishment the number of rats was reported to have considerably decreased. It was remarkable that very few dead bodies of rats were found, even in the instances in which the most effect seemed to be produced. Dr. Abel considered that the method, though not invariably efficacious, was worthy of a trial, and that it might be valuable when plague was imminent, and when rats had to be destroyed as much as possible.' (From *Public Health*, March, 1902.)

'Rosenau [*vide* 'An Investigation of a Pathogenic Microbe applied to the Destruction of Rats,' Bulletin No. 5, by M. J. Rosenau] obtained cultures from the Pasteur Institute, and his experiments were entirely laboratory ones. He agrees with Danysz that, if eaten in large amounts, the cultures are fatal, though their virulence is unstable, especially on exposure to light and air.

Doses short of fatal ones give immunity, and consequently rats, so rendered immune, may eat large amounts of the virulent cultures without harm. The infection caused in the rats has very slight power of propagation from rat to rat, and to be of any practical use the cultures must be so spread about as to be eaten by as many rats as possible. He agrees with Dr. Abel that the virus may be used as one of the means to fight against rats, but is far from being a sure means of exterminating these rodents in a particular place. The cultures are harmless to man and domestic animals, and so have an advantage over chemical poisons; but, as the injection of non-fatal or less virulent doses only produces immunity, they have this great disadvantage over chemical poisons The immunity so produced is very positive, and lasts for several months, and, in his experiments on 115 rats, only 46 were killed, although the conditions for feeding and insuring ingestion were much more favourable to the fatal action of the virus than could possibly be the case in Danysz's experiments with rats in a free state.' (From *Public Health*, March, 1902.)

Further details regarding the destruction of rats will be found in Appendix A

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means. Such measures should obviously include the controlling of the movements of passengers by sea and land, thorough disinfection of their personal effects when necessary, and the destruction of rats on ships before the taking in of cargo.

A. MEASURES FOR THE PREVENTION OF THE SPREAD OF PLAGUE BY SEA-TRAFFIC.

(1) OUTWARD TRAFFIC.

At an international Conference held at Venice in March, 1897, it was ruled that, in the case of vessels leaving infected ports, every person proceeding on such should be medically examined on shore immediately before embarkation; that those showing undoubted or suspected symptoms of plague should be prevented from embarking; and that every infected or suspected article of clothing and personal baggage should be disinfected on shore.

In conformity with this enactment, regulations were framed which provide for a very thorough medical examination of all persons leaving infected ports, and for the disinfection of their baggage.

These rules have been in force for about six years, and there can be no doubt that the strenuous efforts which have been made to give effect to them have

CHAPTER X

MEASURES FOR THE PREVENTION OF THE SPREAD OF PLAGUE

General remarks—A. Sea-traffic: (1) Measures for departing vessels—(2) Measures for vessels arriving—B. Land-traffic: (1) Measures against travellers other than by railways; Cordons; Surveillance of arrivals from infected places—(2) Measures against railway passengers; (*a*) Inspection of all passengers from infected districts, and removal of plague and suspicious cases from trains; (*b*) Disinfection of baggage; (*c*) Disinfection of infected railway carriages—Principles upon which inspection posts should be selected—Classes of post necessary in different circumstances—Concluding remarks.

As in the case of other epidemic diseases, our measures for the prevention of the spread of plague should be mainly directed against what the strongest evidence points to as the most important ætiological factors. The disease is mainly spread by human beings, infected clothing or effects, and ship-borne rats. It is therefore necessary to employ measures to guard against infection being diffused by these

PLATE XV



PRELIMINARY EXAMINATION OF PASSENGERS ABOUT TO EMBARK, AS CARRIED OUT AT THE PORT OF BOMBAY

... Album compiled by Mr. ... B. Stewart

led to success in the prevention of the spread of infection by human beings and infected baggage. Nevertheless, the plague has spread, and continues to spread. The question, therefore, arises as to whether the measures are sufficient; and, in the absence of any scientific evidence to the contrary, the spread of the disease beyond the seas seems to suggest a negative reply.

In what direction, therefore, it may be asked, should they be supplemented? It has been seen that merchandise is only under exceptional circumstances a factor of any importance in plague dissemination; and, as far as sea-traffic is concerned, it may be safely disregarded. The only remaining agency, therefore, which might well be a fruitful cause of the spread is the ship-borne rat.

Koch* stated before the Tuberculosis Congress in 1901 that there was no longer any doubt that, in by far the majority of cases in which the plague had been transmitted by ocean traffic, the transmission had taken place by means of the ship rats, adding that it was high time that this enlarged knowledge of plague ætiology should be utilized in international as well as in other traffic.

* *Public Health*, March, 1902, p. 331: article by Dr. D. S. Davies.

Manson,* in 1899, at the opening of the London School of Tropical Medicine, insisted upon the necessity for dealing with plague as essentially a rat-borne disease, and of adapting our repressive measures to newly ascertained conditions, instead of moving blindly along haphazard routine lines sanctioned by tradition and custom, but inapplicable to the end in view.

The danger of permitting large numbers of infected rats being carried from port to port is not obvious to the public, because the infection does not seem to spread to the crews of vessels. Apart from the fact, however, that the circumstances of board-ship life and a sailor's environment are not conducive to the plague bacillus gaining a foothold among crews, Dr. Davies† reminds us that crews have very little to do with cargoes on a voyage or with loading or unloading them at ports It is upon the quay or dock labourers that such work devolves, and it is they who run the risk of becoming infected, or of acting as carriers of infection in their clothes to people living in the ports.

Thirteen dead rats were found in the forehold of

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a ship which arrived in Bristol in January, 1901, fifteen days out from Smyrna. Klein,* having confirmed the death of certain of these from plague, the ship was dealt with as 'infected,' and in the process of disinfection no fewer than 226 rats were killed.

This led to an appeal, on the part of the Liverpool Sanitary Authorities, to the Local Government Board for the revision of plague regulations, and to the Board approving of the proposed modifications in the case of incoming vessels. As, however, it is impossible to destroy all rats on a loaded vessel, but a simple matter to do so in an empty one, it would, obviously, be more desirable that the rules relating to departing vessels should be modified, and that such modification should take the form of including a scheme for the destruction of rats prior to loading.

It is essential that an uniform method should be adopted at all ports. Opinions are divided as to which is the best method, but most authorities consider that fumigation with sulphur dioxide gives the most satisfactory results.

A Commission† consisting of Monsieurs Vergote, Depaire, Vleminhx, F. Putzeys, and Van Ermengen, issued a report to the Belgian Council of Hygiene

* *British Medical Journal*, August, 1901.

† *Public Health*, March, 1902, p. 367.

(*Bull. du Service de Santé*, December, 1901), to the effect that, although they do not believe sulphur fumigation to be a reliable or efficient means of *disinfection*, they recognise that it is an agent of great value for destroying rats and rat vermin. They express themselves as favourably impressed with the results obtained by the 'Clayton' method,* a system which was introduced at New Orleans in 1890-91, when Mr. T. A. Clayton was Chairman of the Quarantine Committee, and which consists in driving gas, produced by the combustion of sulphur in a special apparatus, into the lower parts of the holds of ships (made as air-tight as possible), and extracting the air from the upper parts until the whole of the air-space is permeated with the gas to the extent of 10 per cent., the extracted air being passed over the heated sulphur in the furnace. As the apparatus is worked upon the decks of vessels, or barges adjoining them, there is no risk of fire. One pound of sulphur is used for every 400 cubic feet of space, 3 per cent. of the gas in the air being fatal to rats; the expense for fumigating a ship would be at the rate of 20s. for every 100 tons gross register.

The Director of Quarantine at Alexandria,†

* *Public Health*, March, 1902, pp. 368, 369.
† *Ibid.*, p. 366.

reporting to the President of the Quarantine Council of Egypt, stated that his results with sulphur fumigation had been very satisfactory; he also recommended the disinfection and pumping out of bilge-water, in which fragments of the bodies of dead rats are often found.

Dr. Harker,* Medical Officer of Health of Tynemouth, at a meeting of the Association of Port Sanitary Authorities at Hull, stated that, in his experience, fumigation with sulphur dioxide gave the most satisfactory results in exterminating rats, mice, and vermin.

Dr. Ashburton Thompson (Sydney)† reports that his experience showed him that rat destruction on ships could be effected to a useful extent by fumigation with sulphur carried out as it was during the Sydney outbreak; that the practice is not difficult to secure; and that if vessels which engage in coasting voyages lasting three weeks to a month are fumigated at the port of departure before loading, and at the ultimate port touched on the voyage, few and often no rats are discovered to remain; this statement applying to steam-vessels of various tonnages up to 4,000.

* *Public Health*, March, 1902, p. 336.
† *Ibid.*, pp. 335, 339.

As pointed out by Dr. Davies,* there are signs that the commercial world in England would willingly accept reasonable measures designed for securing rat-free ships. In 1901 the Bristol Chamber of Commerce, having obtained extensive information from other important shipping centres in England bearing on the subject, proposed the following resolution at the meeting of the Associated Chambers of Commerce at Nottingham, it was seconded by Greenock, supported by Halifax and Southampton, and carried by an overwhelming majority.

'That, as it appears desirable in the interest of the public health to minimize opportunities for the introduction and dissemination of diseases by ship-borne rats, it is of importance that regulations made for this purpose should be so framed as not injuriously to affect the trade and commerce of the country. This Association therefore recommends that the captains of vessels loading at plague-infected ports should be ordered to destroy rats on board ship before loading cargo, and to take precautions to prevent rats getting on board during the time cargo is being loaded, and that British consular certificates should be issued to captains obeying such orders. The Association further resolves that a copy of this

* *Public Health*, March, 1902, p. 335.

resolution be sent to the Board of Trade and the Shipowners' Association.'

(2) INWARD TRAFFIC.

The Venice Convention also rendered it necessary that certain regulations should be enforced in the case of vessels arriving from infected ports. These rules require that—all vessels arriving from infected ports, or which have plague on board, or which have been in communication otherwise than orally or by signal with vessels from infected ports, or which have had plague on board within twelve days before arrival, should, before entering port, hoist a yellow flag by day and show the quarantine light by night, till permitted by the Health Officer of the port to remove it:

that, until receiving pratique, they should not hold any communication with the shore, except orally or by signal, or with any other vessel, saving that the Health Officer, Pilot, and Police or Customs Officer, may be taken on board; and that, after inspection by the Health Officer, they be classified according to circumstances as 'infected,' 'suspected,' 'ordinary healthy,' or 'healthy:'

that, if 'healthy,' the examination of those on board or the disinfection of any of their effects

should rest at the discretion of the Health Officer: if 'ordinary healthy,' that all on board should be examined, and their effects disinfected if necessary, those likely to spread infection being detained under observation in a place set apart, the rest of the crew being kept on board under the Health Officer's observation, and the remainder of the passengers being required to comply with whatever written directions they may receive from him: if 'suspected,' that, in addition to the above, all parts which have been occupied or frequented by plague patients should be disinfected, and such other parts also as the Health Officer may deem necessary: and if 'infected,' that, in addition to all these precautions, the sick should be landed and isolated

that persons under observation should be detained for such period, not exceeding ten days, as may be determined on, having regard to the sanitary condition of the vessel and the manner in which it has been classed. In the case of an 'ordinary healthy' vessel, that the detention should terminate on the eleventh day from the departure of the vessel from an infected port, or the date of her communicating with a vessel from an infected port, whichever is more recent

that, should a case of plague occur among those under observation, the patient be isolated and a fresh period of ten days' detention enforced on others in the camp, commencing from the date of removal of the patient.

From the evidence laid before the Indian Plague Commission* regarding the working of these rules, they consider that the results do not compensate for the labour and expense involved in examining passengers arriving from one infected port to another; but that, if it be considered necessary to maintain this form of examination, free pratique should be given to a 'healthy' or 'suspected' ship without any further formalities, provided no case of sickness has occurred on board. They further consider it undesirable to make any difference between a 'healthy' and an 'ordinary healthy' vessel; and think that all that is necessary in the case of an 'infected' ship is to land and isolate the sick, to disinfect the ship and the effects of those on board, and to permit passengers to be kept under observation at their own homes for a period not exceeding ten days, only those being sent to camps who cannot be kept under observation at home.

* 'Report of the Indian Plague Commission,' chap. vi., p. 388.

B. MEASURES FOR THE PREVENTION OF SPREAD OF PLAGUE BY LAND-TRAFFIC.

It is as desirable that protection should be afforded to uninfected areas of land adjoining infected tracts as to places beyond the seas Measures are therefore also necessary to guard against the possible spread of infection by passengers travelling by land.

It is manifestly impossible to organize such measures without granting concessions which might defeat their aim; or to bring them to such a state of perfection that all possible means of evading them could be obviated, without practically closing the channels of daily communication and paralyzing trade.

Palliative means are, therefore, all that can be adopted; but, for any measure of success, it is necessary that such should be sufficiently strict to act as a powerful deterrent against infected persons travelling and those from infected districts carrying obviously contaminated baggage. Regulations which would provide for this cannot be applied with any degree of satisfaction except in the case of railway passengers. As, however, plague has been observed, during recent Indian epidemics, to spread principally

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From the evidence laid before the Indian Plague Commission* regarding the working of these rules, they consider that the results do not compensate for the labour and expense involved in examining passengers arriving from one infected port to another; but that, if it be considered necessary to maintain this form of examination, free pratique should be given to a 'healthy' or 'suspected' ship without any further formalities, provided no case of sickness has occurred on board. They further consider it undesirable to make any difference between a 'healthy' and an 'ordinary healthy' vessel; and think that all that is necessary in the case of an '*infected*' *ship is to land and isolate the sick, to* disinfect the ship and the effects of those on board, and to permit passengers to be kept under observation at their own homes for a period not exceeding ten days, only those being sent to camps who cannot be kept under observation at home.

* 'Report of the Indian Plague Commission,' chap. vi, p. 388

they are with countless paths and tracks, present great obstacles to the success of a cordon. In certain cases, however, as at Malir, where there is virtually a cul-de-sac, or where there is a river fordable only at certain definite and well-known places, the physical difficulties are less. In such cases an attempt to restrict the movements of the people by means of a cordon may meet with some measure of success. Where, again, the infected area is very limited, and very strong establishments can be concentrated upon it, the restriction of the movement of the people by means of a cordon, if it could not be made absolute, could be made nearly so, provided that reliance could be placed on the watchfulness and the integrity of those employed on the cordon. But we fear that this is rarely the case in India. the men cannot be depended upon to remain at their posts, awake and alert; and they cannot be trusted to refuse bribes The consequence, therefore, will almost always be that, even in the rare cases where the physical conditions are favourable to the success of a cordon, the carelessness or venality of the guards on it will bring about failure, and in the great majority of cases the area to be guarded will be so great, and the possibilities of evading a cordon at night so many, that, even

along the lines of railway, it would appear that measures are chiefly requisite in the case of passengers by this means of communication.

(1) LAND TRAFFIC OTHER THAN BY RAILWAYS.

Against travellers other than by railways, the only two feasible methods are cordons round infected places and strict surveillance of persons arriving in uninfected areas.

As regards the former, the conclusions of the Indian Plague Commission* are, generally, in accordance with the views held by those who have had experience of the measure. They report that, 'unless circumstances are very specially favourable, the attempt to keep a large mass of people in or out of a particular place by means of a cordon or a similar device is doomed to failure. It must be admitted that a cordon has a moral effect, and that it may by this means deter people from passing in or out of a cordoned place unless in the case of persons who have strong motives for doing so. But under ordinary circumstances the physical characteristics of the plains of India, covered as

* 'Report of the Indian Plague Commission,' chap. vi., p. 399.

they are with countless paths and tracks, present great obstacles to the success of a cordon. In certain cases, however, as at Malir, where there is virtually a cul-de-sac, or where there is a river fordable only at certain definite and well-known places, the physical difficulties are less. In such cases an attempt to restrict the movements of the people by means of a cordon may meet with some measure of success. Where, again, the infected area is very limited, and very strong establishments can be concentrated upon it, the restriction of the movement of the people by means of a cordon, if it could not be made absolute, could be made nearly so, provided that reliance could be placed on the watchfulness and the integrity of those employed on the cordon. But we fear that this is rarely the case in India: the men cannot be depended upon to remain at their posts, awake and alert; and they cannot be trusted to refuse bribes. The consequence, therefore, will almost always be that, even in the rare cases where the physical conditions are favourable to the success of a cordon, the carelessness or venality of the guards on it will bring about failure, and in the great majority of cases the area to be guarded will be so great, and the possibilities of evading a cordon at night so many, that, even

with establishments which could be implicitly relied on, it will be found impossible to make a cordon an effective means for preventing the spread of plague.'

As to *surveillance* of people from infected areas, there can be no doubt that this is a most valuable measure for preventing infection becoming established in an uninfected place. By keeping a watch over persons who are likely to introduce infection, and inquiring into every case of sickness among them, the earliest cases of plague, should any occur, could not escape detection, and by prompt measures the possibiltiy of spread could be obviated.

This measure would naturally be of more service in the country than in towns, as it is easier for travellers to surreptitiously enter a town than a village; but whether in town or country, it would, as pointed out by the Indian Plague Commission,* almost entirely depend for its success on the active and intelligent co-operation of the people themselves, and would, therefore, probably be more effective in places of which the inhabitants have experienced one outbreak, and, knowing its miseries, were anxious to avoid another.

* 'Report of the Indian Plague Commission,' chap. vi., p. 323.

(2) RAILWAY TRAFFIC.

Measures directed against railway passengers should have as their aim the arrest of travelling foci of infection (*a*) by removing such from trains in the persons of plague cases, (*b*) by rendering innocuous, by disinfection, the effects of passengers selected, on definite lines, as being probable carriers of infection*; and (*c*) by rendering innocuous, by disinfection, railway carriages in which plague cases are detected.

As has been seen, the regulations should be sufficiently stringent to powerfully deter the infected and probably infected from travelling, and those from infected districts from carrying obviously contaminated baggage. In measures of this nature, more than any other, the moral effect contributes powerfully to the success. Among other instances which proved this, the following very convincing one came under the author's observation some years ago

At the urgent request of the Great Indian Peninsula Railway administration, the passengers of one daily fast train between Bombay and Poona were exempted from inspection at Kalyan Station (Kalyan being, so to speak, the *railway-gate* of Bombay on

* *Vide* Rule XIII., Appendix B., p. 233.

this particular line), on condition of their being inspected at Poona Station (not only an inconveniently arranged station for the purpose, but at which the train arrived after dark). The result was that, after a few days, this train was known as the *plague* train; the number of cases detected suddenly went *down* at the Kalyan inspection post, and *up* at the Poona post; everyone leaving Bombay, who possibly could, went by this train; hundreds of people had to be shut out for want of room at the barriers, and even the railway officials experienced great difficulty in getting on to the platform through the crowd. The people either trusted to escaping at Poona in the dark, or to alighting at stations short of Poona, and thus evading inspection altogether.

It is only by combining disinfection of suspected baggage with the removal of plague patients and doubtful cases from trains that an appreciably deterrent effect can be produced.

(a) *Removal of Travelling Foci of Infection in the Persons of Plague Cases.*

To accomplish the removal of travelling foci of infection from trains, it is necessary that all persons travelling from infected places should be subjected,

at one or more points *en route*, to a careful medical examination, all those exhibiting undoubted or suspicious symptoms being detained in plague or observation camps connected with the inspection posts.

From the published statistics of the results of railway medical inspection during the recent epidemics in India, it would appear that some hundreds of plague cases have been removed annually from trains. The significance of this is that as many hundreds of centres of infection have been prevented from becoming operative as such in healthy areas. Compared with the many hundreds of thousands of persons who travel, however, this number is exceedingly small; and, indeed, plague has spread, and continues to spread, chiefly along the lines of railway communication. The presumption is, therefore, that such spread has occurred either by means of infected persons passing inspection posts, undetected, while only in the incubation stage; or that, while not being themselves infected, many persons have carried infection in their baggage.

As regards the first of these contingencies, as has been seen, the observation of a very large number of passengers detained as suspicious, and in whom undoubted symptoms of plague subsequently appeared, goes to demonstrate that the incubation stage is

seldom unaccompanied by some such premonitory sign as pyrexia, giddiness, suffused conjunctivæ, etc.; and as practically all persons showing such signs have been detained as suspicious, the probabilities are that very few cases—if any—in this stage have escaped detection. *It is therefore extremely unlikely that, with thorough inspection, dissemination occurs to any extent by persons in whose bodies the plague may be incubating.*

It is much more probable that the infection is *spread by persons carrying infected baggage.* Numerous instances have been recorded which demonstrate that a healthy place may become infected by the introduction of infected clothing by persons (themselves not infected) arriving from *infected areas. Collie recounts the following striking* case:

A man whose wife died of the plague in Bombay left, a few days after losing her, for his native village (in an uninfected area), taking her clothes and ornaments with him. Shortly after his arrival rats commenced to die in and about the house. The inmates then sickened and died, the man himself being the sixth to be attacked. The infection then spread through the whole village.

It seems obvious, therefore, that the measures

should include the disinfection of the effects of such passengers as are probable carriers of infection.

(b) *Disinfection of Baggage.*

The most rapid method of carrying out disinfection of suspected baggage is by subjecting it to saturated steam under pressure, but where this cannot be done, or time is of no particular importance, it can be effected by boiling the things in water or soaking them in chemical disinfectants, and subsequently drying them in the sun, or, in wet weather, over charcoal fires.

Silk, woollen, or leather goods, which would be injured by steaming, boiling, or chemicals, should be spread out in layers or hung up on lines, and exposed thus, for some hours, to the direct rays of the sun

The disinfection of suspected baggage may reasonably be expected to lead to hundreds of thousands of foci of infection being stopped annually from becoming operative as such; and, unless such disinfection be included, the results of a system of medical inspection of passengers could never be expected to be commensurate with the cost—firstly, because the deterrent effect of the system would be inconsiderable as far as controlling an exodus is

concerned; and, secondly, because only very small numbers of foci would be arrested as compared with those if disinfection were superadded, while the inclusion of the latter would not materially add to the cost after the initial outlay upon plant had been incurred.

(c) *Disinfection of Infected Railway Carriages.*

If there be reason to believe that railway carriages from which plague cases have been removed have become infected, it is necessary to subject them to thorough disinfection as soon as possible, in order to protect the travelling public.

The best agent for this purpose is mercuric chloride, which should be used in the same manner as for the disinfection of dwellings; cushion stuffing and covering should, if necessary, be destroyed and renewed.

PRINCIPLES UPON WHICH RAILWAY INSPECTION POSTS SHOULD BE SELECTED.

Inspection posts are desirable—(1) between a province generally and the principal distributing centres of infection; (2) between infected districts as long as the epidemic is on the increase in these districts; and (3) between infected and free districts.

The utility of (2)—or the examination of passengers between infected districts—is likely to be questioned. It has, nevertheless, several important bearings. When contiguous districts are infected, and the epidemic is gaining ground therein, if there were no means of limiting the free spread of plague by arresting as many travelling foci of infection as possible, the infected would travel freely and infect railway carriages, and thus, directly and indirectly, constitute a severe source of danger to the travelling public; the epidemic would also become more widespread, and very many more units in the districts would become infected, entailing untold misery and a vast outlay of money in plague measures.

As regards the class of post necessary to meet the above requirements, there should be *permanent* posts at such stations as might be regarded as the *railway-gates* of the principal distributing centre or centres of infection, with arrangements for steam-disinfection of the baggage of passengers At these posts disinfection might be greatly relaxed, or stopped altogether, during the intervals between the annual or periodical exacerbations, but medical inspection would be necessary as long as plague continued in the centres, even in an endemic form.

By *permanent* posts those are not necessarily im-

plied at which measures need always be in force, but such at which measures might be started at a day's notice if necessary, camps, hospitals, equipment, etc., beingalways ready for use.

Similar posts should be maintained at important junctions, especially those at which lines from several districts meet. In a widespread epidemic, measures at such posts could be employed in any one or more of several directions at the same time; and *by having posts at junctions at which trains have to* wait for railway purposes there would be no likelihood of interference with the companies' time-tables.

Small *temporary* posts are desirable between infected and free districts, and between infected districts while the epidemic is gaining ground therein. These should be arranged on the *flying-column* principle, tents being used for camps, hospitals, and quarters, and portable arrangements being provided for disinfection of baggage by boiling in water or soaking in disinfectant solutions.

It is important that the staff trained for this particular branch of plague duty should, as far as possible, be retained for this duty only, being always kept available for it, even if, when not required for it at any particular time, employed elsewhere

It should also be remembered that the value of

measures directed against railway passengers would be much enhanced, and their popularity assured to the travelling public and the railway companies, were the different local Governments concerned in limiting the spread to adopt an uniform system. Inspection posts should succeed one another on a definite plan arranged with due consideration to the interests of the different railway administrations and the public, and to the safety of the areas for which protection is sought; and not only the same rules, but also the same concessions and exemptions, should apply alike everywhere.

Bearing in mind the fact that rats may travel in goods trains, it is well to supplement the measures by a scheme for destroying these animals in goods vans and sheds, especially in those in which grain is carried or stored.

In conclusion, while it is obviously incumbent upon the authorities of infected places to widely notify the fact of the appearance of infection, it cannot be too strongly emphasized that such notification, as pointed out by Dr. Ashburton Thompson,* would come too late were it deferred till the infection appeared among human beings, a primary epizootic among rats being neglected or treated as only of

* *Public Health*, March, 1902, p. 329.

plied at which measures need always be in force, but such at which measures might be started at a day's notice if necessary, camps, hospitals, equipment, etc., beingalways ready for use.

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It is important that the staff trained for this particular branch of plague duty should, as far as possible, be retained for this duty only, being always kept available *for it, even if, when not required for* it at any particular time, employed elsewhere.

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APPENDIX A

The following circular regarding the prevention of plague has been issued at Glasgow, Liverpool, Bristol, and other cities, modified to meet local requirements in each place.

TO OWNERS AND OCCUPIERS, WAREHOUSEMEN, AND OTHERS.

'Whereas it is expedient that rats in every English city should be destroyed, the Health Committee invite the careful attention of owners and occupiers, warehousemen, and others, to the following memorandum, and their co-operation in the measures suggested, which for the greatest safety would be best carried out before any actual invasion occurs. Participation in this work should be accepted by every citizen as part of his municipal duty at the present time.

'In the event of the introduction of plague into the city, its extension would be best met—

'(1) By wholesale destruction of rats;

'(2) By their exclusion from dwellings, warehouses, and places of business generally, and by the destruction of their haunts and feeding-places in the vicinity of dwellings.

'To be effective the efforts must be general, and strict watch should be kept for the appearance of rats in places not at present infested by them.

secondary importance. Much time would undoubtedly be gained, and additional protection secured, were such an epizootic considered sufficient grounds to warrant a declaration of infection being established in any place in which it might occur.

'Slaughtermen and others are warned that contraventions of, and neglect to observe, the bye-laws with regard to the removal of garbage are punishable

'All household refuse should, as far as possible, be burned by the householder.

'The Health Committee rely on the willing co-operation of landlords and householders in these directions, and tenants will forward the work of repression by informing them of premises which are rat-infested.

'To DESTROY RATS

'Trapping and poisoning are the most readily available methods; hunting with dogs, ferrets, or a mongoose, is sometimes practicable, but they can rarely follow the rat into its burrow

'*Trapping*—The most useful form of trap is a spring-trap, baited with ham. Cage traps are too large, and the rat soon learns to avoid them.

'*Poisoning*—Some form of arsenic or phosphorus paste is to be preferred. There is no available poison which will preserve the dead rat from putrefaction and prevent smell.*

[*Signature*] — — — — — —

Medical Officer of Health

* From *Public Health*, 1902, pp 370-372

'Rats gain access to buildings chiefly—

'(1) By burrowing through the earth below wooden flooring;

'(2) Along the course of drainage and other pipes led through main walls in holes which are too large, and up the course of rain-water pipes;

'(3) By badly-fitting doors, doors broken at the foot, and other openings on the ground-floors.

'This is to be met—

'(1) By cementing or asphalting earthen basements when these are burrowed;

'(2) By packing loosely-fitting holes through which drain or other pipes pass;

'(3) By refitting doorways, protecting the foot if necessary with sheet-iron, and by protecting openings in basements by wire netting if nothing better can be done.

'Rat-runs in buildings should be discovered and destroyed.

'It is useless to stop rat-holes in a house and leave the means of access to the tenement still open. Rats overrun a building behind the plaster and woodwork, in the casing of pipes, and below flooring, but they gain access at the basement.

'Rat-infested premises may be dangerous to the health of the tenants, and a menace to their neighbours, and may thus be dealt with under the Public Health Acts.

'Landlords are requested at once to inquire into the presence of rats on their properties, and to take action on the above or on similar lines

'Rats are attracted to buildings in search of food.

'Ashpits, collections of garbage, stable-yards, etc., afford them food; lumber-heaps or disused structures are suitable for nesting.

'Owners are reminded that ashpits that are allowed to be a nuisance may be dealt with under the Public Health Acts.

to examine the doors of carriages for ascertaining whether or not they are locked,

(vi.) Men and women at the spots indicated by the Senior Inspecting Officer, whose duty it will be to place clinical thermometers in the armpits of those passengers put aside to have their temperatures taken;

(vii.) One clerk or other subordinate at the table provided for filling in guards' certificates and the other clerical work necessitated by these rules.

(*b*) That the indices of all the clinical thermometers are well below the normal point.

(*c*) In conjunction with the Station-master, that the platform, so far as is necessary, is clear of all except officials on duty.

(*d*) That the local third-class passengers—who with other local passengers should be examined before the arriving train is signalled—are so kept within a barricaded portion of the platform as to prevent the possibility of their entering the train until the arriving passengers shall have been examined.

II.—Immediately upon the arrival of a train, the Senior Inspecting Officer shall satisfy himself that all carriage doors are locked, making a note of any that may not be, and having them locked before the examination of passengers commences.

III.—The inspection of first and second class passengers will then proceed. This shall be carried out in the first and second class carriages, a female inspecting officer being detailed to examine female passengers, who should, if they so prefer, be taken for the purpose to the special compartments reserved in those classes for female passengers.

IV.—The inspection of the passengers in the third class will next be held. Males will be examined on the platform and females in a special enclosure by female inspecting officers.

APPENDIX B

The following regulations, extracted from Executive orders issued in 1898 by the Government of Bombay (in connection with measures, then in force, against the prevention of the spread of plague by railway passengers), are appended here as likely to prove of benefit, as a practical guide, to those upon whom may devolve the organization of measures on the principles laid down in Chapter X. of this work.

RULES FOR THE GUIDANCE OF INSPECTING MEDICAL OFFICERS AT RAILWAY-STATIONS.

I.—Immediately upon an arriving train being signalled, the Senior Inspecting Officer shall satisfy himself—

(*a*) That all members of the staff are at their posts as follows:

(i.) Male and female inspecting officers on the platform;

(ii.) One policeman at each end of the platform;

(iii.) One policeman in a barricaded portion of the platform for the purpose indicated in clause (*d*) of this rule;

(iv.) One or two policemen on the off side of the line to prevent passengers from getting down on that side;

(v.) One or two policemen on the platform in readiness

supernormal, allowing those with normal or subnormal temperatures to proceed if he thinks fit, and causing the attendants to wash the thermometers and have their indices shaken down again, so as to be in readiness for a fresh batch of passengers to be subjected to the thermometer test

N.B —(*a*) Any sick passenger holding a certificate(Form $\frac{A}{B}$) signed by a commissioned medical officer or by a specially authorized medical practitioner (signed and dated not earlier than one day previous to the commencement of the journey), certifying the illness from which the person is suffering, and that the person is free from suspicion of plague, and describing the person sufficiently for purposes of identification by the entry of one or more indelible marks, will be permitted to travel without detention to his or her destination.

(*b*) Persons travelling with certificates of inoculation, provided the date of such inoculation is certified to be within the last six months, but not within ten days immediately preceding, and the identity of the holder is not open to doubt, will ordinarily be allowed to pass with the examination prescribed for first and second class passengers, except that they will probably be required to detrain.

(*c*) To save time, at disinfecting-stations, the clinical thermometer test need not be applied till after departure of the train to such persons as would in any case be detained for the purpose of having their clothing and baggage disinfected.

IX —If there be time before the starting of the train, after the primary inspection, for a more detailed examination of those set aside, the Senior Inspecting Officer shall decide which of them should be detained and which should be allowed to proceed, having regard to (*a*) the height of the temperature, (*b*) the presence or absence of suspicious symptoms, and (*c*) the place from which they may be travelling.

N.B —Passengers coming from districts free from plague, or places at a distance from infection, need not be subjected to the clinical thermometer test, but this test should be

N.B.—At stations where disinfection arrangements exist, each passenger will alight with his or her bundle for inspection by the inspecting medical officers as to whether or not the contents require disinfection.

V.—The inspection under Rule IV. will be carried out *either by (a) emptying one carriage at a time, or (b)* by emptying all the third-class carriages, and causing the male passengers to be drawn up in a line clear of the train for inspection, and the female passengers to be taken to a special enclosure. Each carriage as it is emptied should be thoroughly searched by a policeman.

VI.—All passengers whose temperatures may be in the least degree above normal are to be subjected to a detailed and searching examination. 'Passengers, therefore, who at the primary examination exhibit the least sign of a rise in temperature shall be set aside to be subjected to the clinical thermometer test, which is to be regarded and treated as the salient feature of the system.

N.B—For the selection of those whose temperatures are to be *taken, the temperature of the skin of the body to the* touch and the state of the pulse afford ready guides, and if these do not indicate the necessity for taking of the temperature, the inspecting medical officer may institute such further examination as he considers necessary, and either allow a passenger to proceed or detain him or her for further examination according to circumstances.

VII.—All passengers selected for the clinical thermometer test will be passed on to the staff appointed for placing the thermometers in their armpits, care being taken that this duty will be done, if possible, for each passenger by a person to whom no reasonable objection can be taken on account of caste, and for women by women.

VIII.—When it is reported to the Senior Inspecting Officer that all the available thermometers are in use, he shall cause a rapid examination of the thermometers to be made, placing on one side all those passengers whose temperatures are

XIII —At stations where disinfection arrangements exist, thorough disinfection by steam of clothing and bedding will be employed in the case of persons who are believed to carry infection, either as coming from a plague-stricken locality and having lived with people amongst whom plague has been prevalent, or from the sordid condition of their baggage or clothing. Detention for the process of disinfection should not occupy more than a few hours.

XIV.—The name and address and destination of each person whose temperature has been taken or whose effects have been disinfected will be recorded on a ticket (Form $\frac{C}{R}$) bearing a consecutive number of that day's issue

N.B.—Presentation of this ticket, under precautions as to identity and as to verification of residence, will procure for the traveller entrance into any town, subject to a second test of the temperature should the authorities of the town consider it necessary, and subject to any local regulations framed for persons who cannot be trusted under the surveillance system. The ticket will ordinarily be operative for twenty-four hours only

XV.—No train the passengers in which have to be examined shall be allowed to leave an inspection-station until the guard in charge shall have received a certificate in Form $\frac{D}{R}$.

XVI —A daily return in Form $\frac{E}{R}$ shall be submitted to the supervising medical officer of the medical inspection of railway passengers.

applied as far as possible to all third-class travellers from an infected locality or its neighbourhood.

X.—Of those detained after the departure of the train a searching examination should be made, in order to decide as to which of them may be permitted to proceed in the following train, and as to which should be detained for observation. The Senior Inspecting Officer shall have full discretion to permit an individual with a temperature in excess of normal to proceed. The fact and the reason for the permission must be intimated to the Plague Authority of the place of destination by telegraph, and this can only be allowed where the destination of the traveller is a place where a second medical examination can be made. In such cases the individual must be placed in charge of the guard, and not allowed to alight till arrival at the place indicated. If, however, the medical officer is satisfied that the excess of temperature is not due to plague, he shall give a certificate (Form $\frac{B}{R}$) stating the cause of illness, and permitting the individual to alight anywhere. Whenever any person is detained, it shall be at the option of members of the same family or party travelling in the same train to remain with such person.

N.B.—Persons detained under observation on account of a suspiciously high temperature will be examined twice daily while such detention lasts, and, if found to the satisfaction of the medical officer to be suffering from disease other than plague, cholera, or small-pox, will be allowed to proceed on their journey without further delay.

XI.—When it so happens that a rapid exodus may be taking place from an infected town, and trains become very much overcrowded, the inspection must on no account be hurried, but such passengers as cannot be examined during the usual stay of the train must be detained till the next train arrives.

XII.—No subordinate will be empowered to order detention or to decide as to the results of examination.

FORM $\frac{B}{R}$

Serial No. ____________

Name ____________

Sex ____________

Father's or Husband's Name ____________

Caste ____________

Address ____________

Destination ____________

Indelible Marks ____________

Disease

Remarks ____________

____
Senior Inspecting Officer,

____________ Station.

Date ____________, 190 .

FORM $\frac{B}{R}$

Serial No. ____________

Name ____________

Sex ____________

Father's or Husband's Name ____________

Caste ____________

Address ____________

Destination ____________

Indelible Marks ____________

Certified that the above individual, suffering from ____________ is free from all signs and suspicion of plague, and may safely be permitted to proceed to $\frac{his}{her}$ destination.

____
Senior Inspecting Officer,

____________ Station.

Date ____________, 190 .

FORM $\frac{A}{R}$

I ______________________ Commissioned Medical / specially authorized in this behalf by the Surgeon

Officer / General with the Government of Bombay, hereby certify that—

Full name ______________________

Age ______________________

Caste ______________________

Occupation ______________________

Present residence ______________________

Place to which proceeding ______________________

One or more indelible marks of identification ______________________

is suffering from ______________________ and is free from suspicion of plague, and may safely be allowed to travel without detention.

Dated at ______________________ *this* ____ *day of* ______________________ 190 .

Signature ______________________

Designation ______________________

FORM $\frac{D}{R}$

Train No. ________

Date________190 .

Time Arr.________

" Dep________

Station ________

____

Senior Inspecting Officer.

FORM $\frac{D}{R}$

To the Guard in charge of Train No.______from________

*Date*________, 190 .

Time Arr. ______ Dep.______

Station________

I hereby certify that, to the best of my knowledge and belief, all persons proceeding by the No. ____Train from________ whether Railway servants or passengers, are free from plague.

____

Senior Inspecting Officer,

________Station.

FORM $\frac{C}{R}$

No.________
Date________________, 190 .
Station________________
Name________________
Sex________________
Father's or Husband's Name } ________________
Caste ________________
Address { ________________
Destination ________________
Indelible Marks { ________________
Temperature at______ $\frac{P.M.}{A.M.}$ } ____________F.
Whether disinfected or not } ________________
Remarks { ________________

____
Senior Inspecting Officer.

FORM $\frac{C}{R}$

No.______of________________190 .
Station ________________
Name ________________
Sex ________________
Father's or Husband's Name________________
Caste________________
Address { ________________
Destination________________
Indelible Marks { ________________

Certified that the above individual has been thoroughly examined, and that $\frac{his}{her}$ temperature was________F. at______ $\frac{P.M.}{A.M.}$
Whether belongings disinfected or not (enter *Yes* or *No*) } ________________

____
Senior Inspecting Officer,
____________Station.

INDEX

FORM $\frac{E}{R}$

STATEMENT showing Result of Inspection by Medical Staff at____________ Station from 12 Noon of____________ to 12 Noon of____________

Classification of Persons detained	Suspected Cases.								Plague Cases.								Total Number of Passengers subjected to the Clinical Thermometer Test.	Total Number of Passengers disinfected.	Remarks.
				Of those in Column 4, the Number who during the 24 hours under Report									Of those in Column 13, the Number who during the 24 hours under Report						
	Number of Fresh Cases detained during 24 hours under Report	Cases remaining at the end of previous 24 hours.	Total.	Have died	Have been found free from Plague and been discharged.	Have been found to be suffering from Plague.	Have been transferred.	Remain under observation at the end of time under Report.	Number of Fresh Cases, excluding those shown in Column 7	Number of Suspected Cases who developed Plague as shown in Column 7	Balance remaining at end of previous 24 hours.	Total.	Have died.	Have been discharged cured.	Have been transferred.	Remain at the end of time under Report.			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
(1) Passengers by up trains																			
(2) Passengers by down trains																			

Signature____________

Rebman, Limited, 129, Shaftesbury Avenue, W.C.